JOURNAL

OF THE

AMERICAN WATER WORKS ASSOCIATION

VOL. 23 MARCH, 1931 No. 3

CONTENTS

JOURNAL
OF THE
AMERICAN WATER WORKS ASSOCIATION

The Association is not responsible, as a body, for the facts and opinions advanced in any of the papers or discussions published in its proceedings
Discussion of all papers is invited

Vol. 23 MARCH, 1931 No. 3

THE ADVANCE PLANNING AND OPERATING RESULTS OF PUMPING FACILITIES AT CHICAGO[1]

By Loran D. Gayton[2]

To the average citizen, a great power plant or a municipal pumping station is just a mass of steel and stone. He often complains that such a structure is a blot upon the landscape, while at the same time admitting that it is necessary to his modern way of living. The average man accepts as his just due the service delivered to him by such a plant, but seldom gives thought or credit to those whose brain and brawn have brought it about and thereby helped to make possible his present luxurious standards of life.

On the other hand, to the engineer who has had a part in the design or construction of a great power plant or a municipal pumping station, that plant is a living thing. To him it represents the realization of the dreams of untold thousands of thinkers down through the ages. The engineer looks through and beyond that great mass of steel and stone and its throbbing machinery; he sees the workers in the drafting room whose minds conceived it, and he sees the toilers in the mine and the field, in the foundry, the machine shop and the rolling mill, who have produced and fabricated the materials and machinery entering into its make-up.

Somebody has said: "An engineer is a dreamer with the ability

[1] Presented before the St. Louis Convention, June 5, 1930.

[2] City Engineer, Chicago, Ill.

to make his dreams come true." I like this definition, for I believe it states a truth. Every great project first takes form as a picture in the mind of some engineer. Then this mind picture must be transferred to paper, and finally this engineer must have the ability to develop these plans into the finished physical structure.

A completed engineering structure, in almost every instance, represents the expenditure of millions of dollars, years of time, and inestimable energy. Those handling the financial side of the proposition, having faith in the technical knowledge and ability of the engineers employed, do not hesitate to authorize the necessary expenditures. The engineer, in his turn, with a firm belief in himself and in his associates, and knowing that his work is based upon a foundation of science, goes forward, never doubting that he will attain the desired results.

In the case of a great municipal pumping station, such as we are now considering, the need of additional pumping capacity is indicated by a growing community, and the designing engineers are called upon to provide a plant adequate to meet the immediate needs of the community and the growing demands of future years. Then there develops in the mind of the designer the dream picture of such a plant, and this dream eventually takes form upon the drawing board, and little by little the drawings are developed to the stage where the manufacturer is called into action. Builders of the many and various types of equipment entering into a power plant, having detailed knowledge of their particular products, and coming from the four points of the compass, coöperate with the designers and with each other, in synchronizing the various parts and in bringing about the desired completed project.

The dream of the designers having been put upon paper in the form of carefully worked out plans, the specifications, covering every item in great detail having been written and the contracts awarded, the desired building material and the equipment, representing the labor of thousands of men in far separated localities, are brought together in one spot and properly connected up into a completed unit. The designers, the manufacturers, and the builders stand back and contemplate the result of their dreams and their labors.

DESIGN OF WILLIAM HALE THOMPSON STATION

And so, to me, the story of the design, construction and operation of the William Hale Thompson Pumping Station in the City of

Chicago is a tale of the achievement of many men. The design of this station was based upon theoretical calculations made in 1923. Four and one-half million dollars worth of building material and operating equipment were brought together and erected, and the station was put in operation in 1928. In 1929 this station was delivering water at a cost within one and one-half percent of the estimate made in 1923.

Before deciding upon the type of station to be erected a careful and detailed comparison was made of various types of pumps, prime movers, auxiliary equipment, and fuel. This comparison led to the selection of centrifugal pumps driven by compound steam turbines, electrically operated auxiliary equipment, water tube steam boilers with underfeed stokers.

At the time of making the studies and comparisons considerable interest in our calculations was shown by water works engineers throughout the country, as was evidenced by the many letters and personal calls received by the writer. Several papers on various phases of the design were prepared for engineering societies and periodicals. Now that the station is in operation, and a full year's operating data available, there seems to be considerable interest among water works engineers as to how close our estimates of cost came to actual operating results. For that reason I feel that this paper will be of value to water works engineers and officials in general. Many of you are familiar with this station, having visited it at the time of the Association Convention in Chicago in June, 1927, but for the benefit of those who are not familiar with it I will describe it briefly.

It is a steam station with four De Laval centrifugal pumps driven through De Laval reduction gears by De Laval compound steam turbines, with steam at 300 pounds pressure and 200°F. superheat at the throttle. Each of the main pumps has a capacity of 75 m.g.d. against 150 foot head. Each turbine exhausts into a 4200 square foot condenser. Steam is furnished by four 600 horsepower Edgemoor boilers, each equipped with an integral Foster superheater. The boilers are served by four Taylor underfeed stokers, with individual electric motor drive. The forced draft is supplied through individual air ducts by four Sturtevant Turbovane fans, which also are electric motor driven. The condensate from the condensers is delivered to open heaters and fed to the boilers by motor driven centrifugal pumps. The small amount of make-up water required is

passed through a double effect evaporator to throw down the scale before entering the boiler. Two 200 kilowatt turbo generators are provided to furnish electric current for the station's power and lighting requirements.

FIXED AND OPERATING COSTS

Table 1 shows a comparison of the most important items of operating conditions and costs as estimated in 1923 and as actually secured under operating conditions in 1929. The 1923 estimates were made in order to compare the costs of different types of stations, and certain items common to all stations were left out, as these costs would in no way affect the comparisons. These items have now been included in table 1.

Under "General Data" it will be noted that the station did 36 percent more work in 1929 than was originally estimated in 1923. The reason for this will be explained in a later paragraph. Under the heading, "Original Investment" it is shown that the first cost of the plant was about 27 percent higher than originally estimated. This increase in first cost was due primarily to the fact that the buildings as originally planned were face brick structures; whereas, due to an administration policy, the buildings as actually constructed were monumental structures with stone facing. Under "Operating Cost Per Year" there is an increase of 34 percent. This increase is made up partly of increased labor cost, over which the designers had no control, partly of increased fuel costs, due to the 36 percent increase in the work performed by the station, and partly due to the increased interest and depreciation charges due to the higher cost of the building. The "Unit Operating Cost per M.G." gives us a comparable item. Here it will be noted that in 1923 we estimated that it would cost $7.37 to pump one million gallons of water; whereas in 1929 the average cost of pumping one million gallons of water was $7.26, or, in other words, the actual cost of pumping one million gallons of water was 1.5 percent less than the estimated cost. If we compare the cost of pumping one million gallons one foot high we find that the actual cost was 0.17 percent less than the estimated cost.

Performance

After the William Hale Thompson Pumping Station was placed in operation, part of the equipment in other stations was taken out of

TABLE 1

Wm. Hale Thompson pumping station comparison of estimated and actual costs

		1923 ESTIMATE	1929 ACTUAL
General data	Total pumpage per year, m.g.	55,850	69,235
	Average pumpage, daily, m.g.d.	153	192
	Maximum pumpage, m.g.d.	217	221.2
	Average head, feet	123.4	136.0
	Coal for year, tons	28,400	37,598
	B.T.U. per pound of coal	11,500	10,400
	Duty, million foot-pounds per million B.T.U.	87.6	101
	Million foot-gallons per year	6,892,890	9,415,960
Original investment, dollars	Land	203,000.00	196,353.87
	Buildings	1,851,415.00	2,751,563.65
	Equipment	1,312,170.00	1,333,492.77
	Miscellaneous	168,330.00	214,070.51
	Total investment	3,534,915.00	4,495,480.80
Operating costs per year, dollars	Labor	78,342.00	143,377.29
	Coal	85,200.00	105.516.74
	Oil, grease and waste	2,000.00	1,796.26
	Miscellaneous supplies and expense	3,000.00	7,576.60
	Chlorine	9,500.00	16,622.37
	Repairs and maintenance	21,807.00	17,902.92
	Interest on investment and depreciation	212,135.00	261,612.46
	Total operating costs	411,984.00	554,404.64
Unit operating costs per million gallons, dollars	Labor	1.40	1.90
	Coal	1.52	1.38
	Oil, grease and waste	0.03	0.02
	Miscellaneous supplies and expense	0.05	0.10
	Chlorine	0.17	0.21
	Repairs and maintenance	0.40	0.23
	Interest on investment and depreciation	3.80	3.42
	Total cost of pumping one million gallons	7.37	7.26
	Total cost of pumping one million gallons one foot high	0.0597	0.0596

service in order to make repairs and to carry out certain tunnel work, and for this reason the William Hale Thompson Pumping Station was called upon to carry the load dropped by the other stations. This accounts for the 24 percent increase in the average daily pumpage, and the 36 percent increase in work over that originally estimated.

The pumpage curve for 1930 as estimated in 1923, and the load curve as actually carried by the station during 1930 are shown in figure 1. The pressure and pumpage curves for the William Hale Thompson Pumping Station on May 14, 1930 are shown in figure 2. This was after the other stations had been put back into service, and the William Hale Thompson Pumping Station was carrying approximately its own load. The original calculations assumed that control

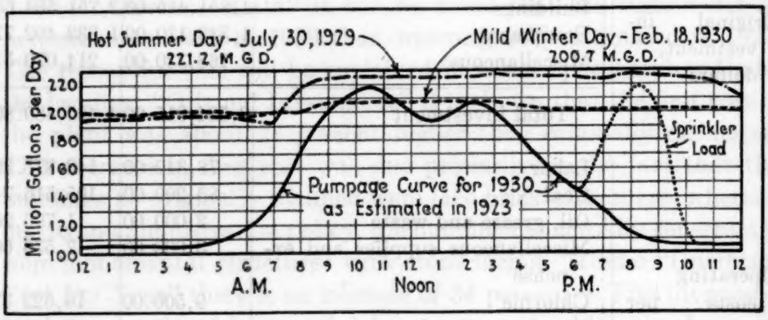

FIG. 1. WM. HALE THOMPSON PUMPING STATION, PUMPAGE CURVES

gauge No. 219 would indicate 25 pounds pressure at all times. The upper part of figure 2 shows that, when the actual station pressure curve approximated the proposed station curve, gauge No. 219 closely approximated the 25 pounds intended. This comparison shows how carefully the friction losses in the distribution system were calculated. With certain minor adjustments to be made in the system it is believed that the pumpage and pressure curves can be maintained very close to those originally intended.

Under "Unit Operating Cost Per M.G." it will be noted that the actual fuel cost was $1.38 per million gallons pumped; whereas, the estimated cost was $1.52. This fuel cost is an indication of the economies achieved in the design and operation of this station. The selection of compound, steam, turbine driven, centrifugal pumps has been justified by the high duty obtained from these pumps, namely,

about 210 million foot pounds of work per 1000 pounds of steam. As far as I have any knowledge, these are the most efficient pumping units of their size ever put in operation.

The remarkable economies achieved in the operation of this station, are further evidenced by the over-all duty of the station as a whole of 101 million feet pounds of work per million B.t.u. in the coal as

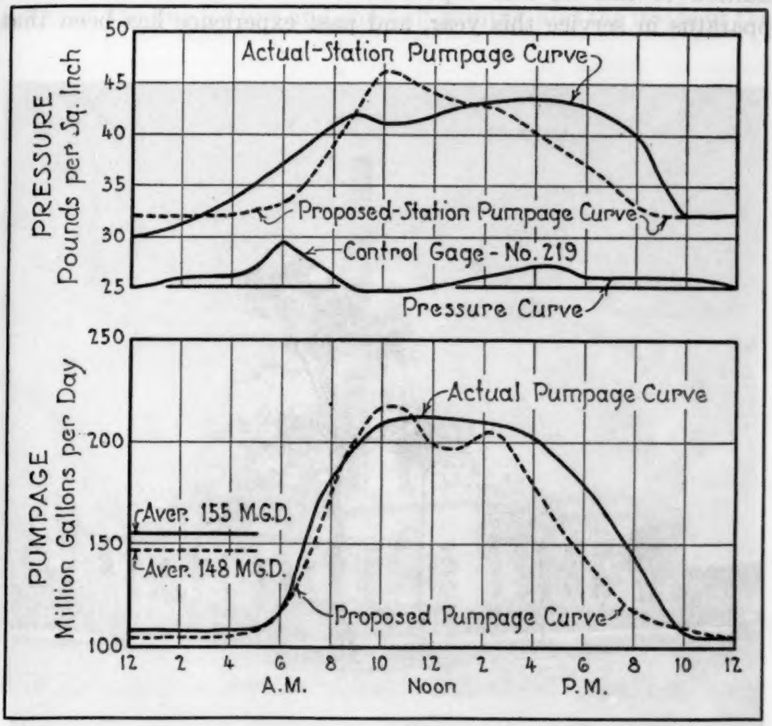

FIG. 2. WM. HALE THOMPSON PUMPING STATION

Pressure and Pumpage Curves, May 14, 1930

fired. Of our older plants the best triple expansion steam station, shows 67.8; the best steam turbine driven station shows 60.8; and the average station duty of our other seven steam stations is 60.8.

Although we are pleased with the operating efficiency of this station, we feel sure that this efficiency can and will be improved this year. It takes time to instruct operators to get the most out of new or strange apparatus. While we have been very conservative in fol-

lowing the trend in power house equipment in designing this station, our operators, who have received most of their experience in other Chicago pumping stations, have not had an opportunity to become familiar with all the possibilities for economy that have been provided. So far we have not taken advantage of the facilities to bleed low pressure steam from the turbine at certain times. In addition to this we also expect to have our combustion control apparatus in service this year, and past experience has been that

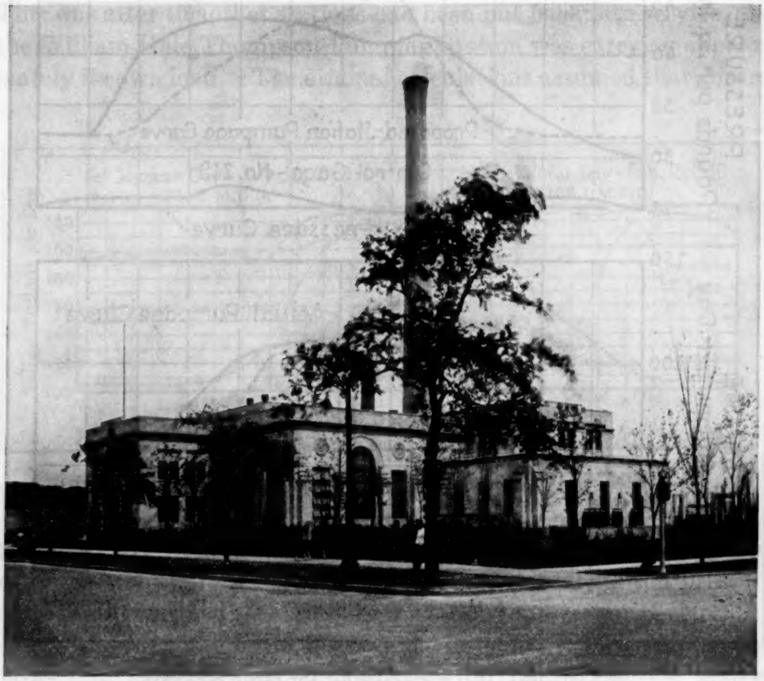

FIG. 3

considerable fuel savings are thus effected. This spring we ran duty trials on the pumps, and a comparison with those run in the summer of 1928 shows no loss in duty. It was not expected that there would be a loss in duty, but a part of the supervision of our pumping stations is a regular program of tests to locate and rectify deterioration of equipment. These tests indicate that what gains we are able to make this year in the boiler room and other places will not be lost in the pump room.

Boiler feed water control

The evaporators for treating the raw make-up boiler feed water have come up to our expectations in every way. The operators have been somewhat reluctant to believe in the entire elimination of scale in the boilers, but increasingly longer runs have proved to them that there is no scale in the boilers. We are now keeping the boilers on the line for five and one-half months, and the inside of the

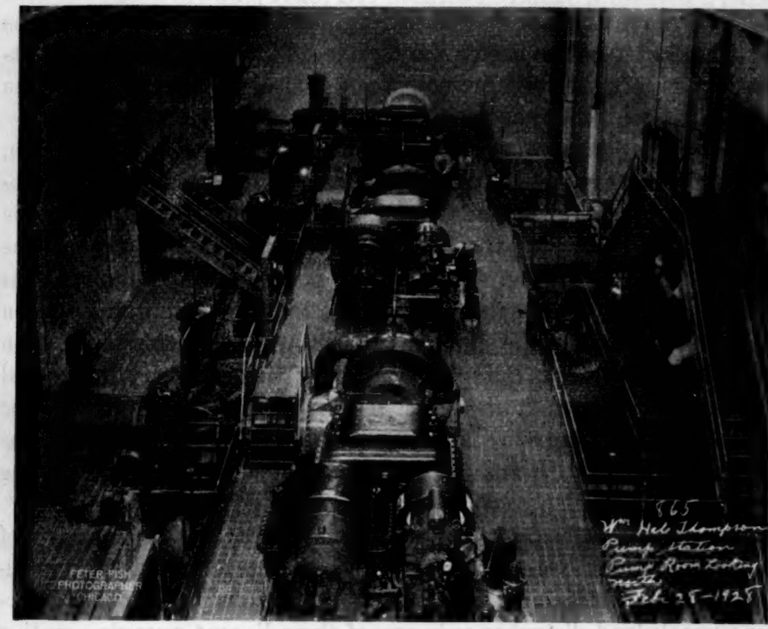

FIG. 4

tubes is still bright and clean. It is really the outside of the tubes that will determine the length of run. Slag and soot and erosion of brick work are now the reasons for taking a boiler off the line, instead of loss of efficiency due to scale. The boilers are blown down twice a week for not more than half a gauge. We do not feel that this is necessary, but it is a carry-over habit from previous operating experiences, and will gradually be eliminated as the operators gain confidence.

Piping arrangement

When this station was designed there was some question as to whether the double header system of discharge from the pumps was worth the additional expense. As the discharge system is designed, each pump can be connected to either or both of the 54-inch headers. There are five 48-inch outlets from this header system so arranged that it is possible to isolate any of the sections of the city adjacent to this station by the manipulation of electrically operated gate valves in the station. One 48-inch line connects directly with the Stock Yards mains; another 48-inch line extends to the feeder mains north and east of the Stock Yards; one 48-inch main extends eastward to supply the territory south and east of the Stock Yards; one 48-inch main extends south and west, and another north and west.

In anticipation of some changes in the Blue Island tunnel system, which will require the complete shut-down of the 22nd Street Pumping Station, we recently made a trial shut-down of this station for one week, and, by isolating the northeast feeder and one pump, in the William Hale Thompson station it was possible to maintain not less than 25 pounds pressure throughout the 22nd Street Pumping Station territory. Again, in the summer of 1928, while lowering the suction pipes at the Roseland Pumping Station, it was necessary for several nights to shut down from 9 p.m. to 5 a.m, and two pumps at the William Hale Thompson station were isolated to feed into the mains to the east and south and thus take care of the Roseland Pumping Station load.

These tests indicate the practical advantage of this design of discharge header system, and it is easy to appreciate what an incalculable value this would have in case of a serious fire or other emergency peak load disturbance in any of the adjacent pumping station territories.

The new station, under normal operating conditions, is very near to the center of load of the area supplied. This is shown by the uniform distribution of its pumpage in the five 48-inch discharge mains, as checked by pitometer measurements under normal load conditions.

To summarize the story of the William Hale Thompson Pumping Station, it is the most modern and efficient municipal pumping plant built up to this time; it has fulfilled in every way the requirements of its designers; it is a credit to those who conceived it, to those who supplied its equipment, to those who built it, and to those who operate it. It is a monument to the engineering profession in general.

DIESEL ENGINES FOR WATERWORKS SERVICE[1]

By Rodney D. Hall[2]

During a meeting of the New England Waterworks Association held in Boston in June, 1923, Dr. Charles E. Lucke presented a paper on the Application of Internal Combustion Engines to Waterworks Service, in which he said the oil engine driven waterworks pump represents a new era in waterworks practice, and added: "The application of the Diesel engine necessarily leads into a different rule of practice than is proper for steam, i.e., the use of a multiplicity of small units in the place of concentrating into units of the largest possible size."

This practice is feasible due to the economy of the small Diesel engine being almost equal to that of the largest sizes.

In comparing Diesel plants with steam driven plants it should also be borne in mind that the Diesel engine is a self-contained power plant, which prepares its own working fluid from the original fuel, and parallels the functions of a combined steam generating and power developing plant.

The oil industry was among the first to take full advantage of the Diesel engine for driving reciprocating oil line pumps. That service is most severe, and continuous for twenty-four hours per day, three hundred and sixty-five days per year.

There can be no question that the Diesel engine in waterworks service is here to stay. Its simplicity, reliability and flexibility as well as its high economy have been fully established.

The increasing field for Diesel engines is described in an article in Power, of April 15, 1930, which says, "The outstanding feature of the recent Aircraft Show, was the Packard radial airplane Diesel."

USE IN WATERWORKS SERVICE

For use in waterworks service, the Diesel engine is suitable for direct connection:

[1] Presented before the St. Louis Convention, June 5, 1930.

[2] Worthington Pump and Machinery Corporation, Harrison, N. J.

To reciprocating geared power pumps
To screw pumps for low heads
To electric generators for use in driving motor driven pumps
To a combination of electric generator and power pump

It is also suitable for connection, through speed increasing gears, to centrifugal pumps for customary pressures for water supply, and in the smaller sizes for driving pumps an l other auxiliaries through belts.

The Diesel Engine Manufacturers Association has furnished me with three lists containing upwards of 100 Diesel engine driven plants chiefly in the United States containing some 200 Diesel engines. The Association states that these lists are not complete, and cover only those installations which are easily obtainable in the records. These lists include:

Group 1. Waterworks plants using Diesel engines

Number of plants	52
Number of Diesel engines	84
Average engine B.H.P.	150
Type of pumps:	*percent*
Centrifugal	66
Displacement	34

All displacement pumps listed are direct connected to their drivers. The oil engine speeds are reduced to suitable pump speeds, by gears forming part of the unit.

The centrifugal pump drives are divided as follows:

Type:	*percent*
Step up gears	30
Motors	39
Belts	31

Group 2. Water and electric plants using Diesel engines

Number of plants	30
Number of Diesel engines	74
Average engine B.H.P.	470

Group 3. Miscellaneous water pumping plants using Diesel engines

Number of plants	18
Number of engines	34
Average engine B.H.P.	215

The average engine horsepowers shown in these three tabulations indicate the present trend of unit sizes, and confirm the conclusions of several recent writers on this subject, that the field best served by

the Diesel engine waterworks pumping units lies in plants of moderate size, where the Diesel drive provides higher fuel economies than are available in steam driven units of approximately the same horsepowers, as well as a flatter fuel consumption curve at partial engine *speeds*, than is produced by steam driven prime movers.

Diesel engine fuel economies are usually guaranteed on a basis of full speed; and full, three-quarter, and half-*load*, which is another way of saying full speed; and full, three-quarter, and half-*torque*. On the other hand, it is not generally known that the fuel economy remains very nearly at the full load value for full torque; for full, three-quarter and half *speed*.

To make the illustration simple, let us assume a 1000 horse power Diesel engine with a full speed of 100 r.p.m. The fuel economy at full load and 100 r.p.m. might be 0.41 pound per brake horse power hour, whereas the fuel economy at 750 horse power and 500 horse power, both at 100 r.p.m. might be 0.43 and 0.49 respectively. However, at 750 horse power and 75 r.p.m. the fuel economy would be practically 0.41, while it might go up to 0.42 at 500 horse power and 50 r.p.m. In waterworks pumping where we have a Diesel engine direct connected through step-up gearing to a centrifugal pump, we have neither constant speed nor constant torque, but a combination of the two. For instance, we might have 92 percent speed and 75 percent of torque, which would be 69 percent of full load. The fuel economy of the Diesel engine should be taken from the full load speed-variable torque fuel curve at the 75 percent point, and not at the 69 percent point.

A similar situation favoring Diesel plants, exists in communities where the rates charged for purchased electric power, are not competitive with Diesel power.

DIESEL ENGINES FOR PUMPING AND GENERATING POWER

Combinations of Diesel engine driven pumping and power generating units can often be used to advantage in municipal plants, following the practice which has gained favor in steam turbine driven units, of combining an electric generator and water pumping unit on the same shaft. Other combinations are equally feasible.

Two examples are:

A *combined* oil engine driven generator and pumping unit consisting of a 400 B.H.P. vertical Diesel engine driving a 270 kilowatt generator with extended shaft connected to a 3200 g.p.m. horizontal

power pump for waterworks service, in the Sioux Falls, S. D. waterworks.

A 600 horsepower vertical Diesel engine driving an alternating current generator and an air compressor from the same shaft. The compressed air is used for an air lift plant, and the electric current operates motor-driven centrifugal pumps. This unit is installed in the plant of the water department of the City of Cleburne, Texas.

Centrifugal pumps suitable for Diesel engine drive, have efficiencies from 70 to 88 percent at the design point, although there are some performance records reaching 90 percent pump efficiency.

As this range is broad, the head and speed ranges with their corresponding efficiencies, are given below:

TYPE	HEAD RANGE	PUMP EFFICIENCY RANGE
	feet	*percent*
Single stage	40–100	78–86
	100–200	75–88
Two single stage in series	200–400	70–88
Multi-stage	Above 400	(Wide variation)

The above classification assumes the minimum size Diesel engine to be 40 to 50 B.H.P., which determines the *minimum* pump capacity, corresponding to the head, and pump efficiency which apply. *Maximum* pump capacity available in the first three head ranges is 75 m.g.d.

Pumping systems can be classified according to their head characteristics. We have five classes, as follows:

1. Constant static head with no friction head.
2. Varying static head with no friction head.
3. Constant static head with friction head.
4. Varying static head with friction head.
5. All friction head.

A *constant speed* centrifugal pump will give only one capacity at a given head.

Thus for system classes 1, 3 and 5, the delivery for a fixed pump speed will be a constant, and cannot be varied except by creating an artificial head, such as by throttling a gate valve on the discharge line. This creates a loss of head, and is inefficient.

For system classes 2 and 4, an increase in static head with a fixed pump speed causes a *reduction* in capacity.

In all cases the highest net efficiencies at partial capacities can be obtained only by variations in the pump speeds. With motor drive, variable speed means electrical losses in the control, which reduce the overall efficiency otherwise obtainable.

ANALYSIS OF WATERWORKS INSTALLATION

Each waterworks pumping installation must be analyzed as an individual case. However, the two prime movers best suited for most efficient variable speed operation, over a reasonable range, are the steam turbine and the Diesel engine.

The installations of turbo-centrifugal pumping units are many, and the operating characteristics are well known.

The number of Diesel centrifugal pumping units in service is not at present as great, and the operating characteristics at partial capacities are less generally known, so a study of such a unit is of interest.

For our example we have taken a unit for a maximum capacity of 15 m.g.d., operating against a total head of 200 feet, and assumed that the head remains constant throughout the capacity range.

This typical installation would be suitable as a high service unit taking water from a filtered water basin, and discharging into the city mains on which a constant pressure at the pumping station is maintained.

As the pump would run at a higher speed than the engine, step-up gears would be used. A 2.5 percent gear loss is included in the power required. The maximum operating range is assumed to be 50 to 100 percent of rated capacity.

The operating characteristics of the several elements of such a unit are shown on figure 1. The Diesel centrifugal unit has a low and relatively flat fuel consumption per water horsepower from 75 to 100 percent of the 15 m.g.d. rated capacity. The total fuel consumption at 75 per cent capacity is 79 percent of the total fuel consumption of 100 per cent capacity, while at 50 percent capacity the total fuel consumption is 65.8 percent of that of 100 percent capacity.

In applying any type of equipment to a pumping problem, consideration must be given to the maximum and minimum capacity requirements, and units of suitable capacities should be selected to give most economical operation.

Assume a station of 45 m.g.d. rated capacity, and a normal capacity of 35 m.g.d, with a night pumpage of approximately 22 m.g.d. For such a station three 15 m.g.d. units would be suitable for the rated capacity of 45 m.g.d. Two units would be operated for pumping rates between 22 and 30 m.g.d., and three units for capacities between 30 and 45 m.g.d. In a station having the above requirements, at least one spare 15 m.g.d. unit should be available.

Figures 2 and 3 showing B.T.U. consumption and fuel costs per useful horsepower hour, are helpful in studies of Diesel engine driven units.

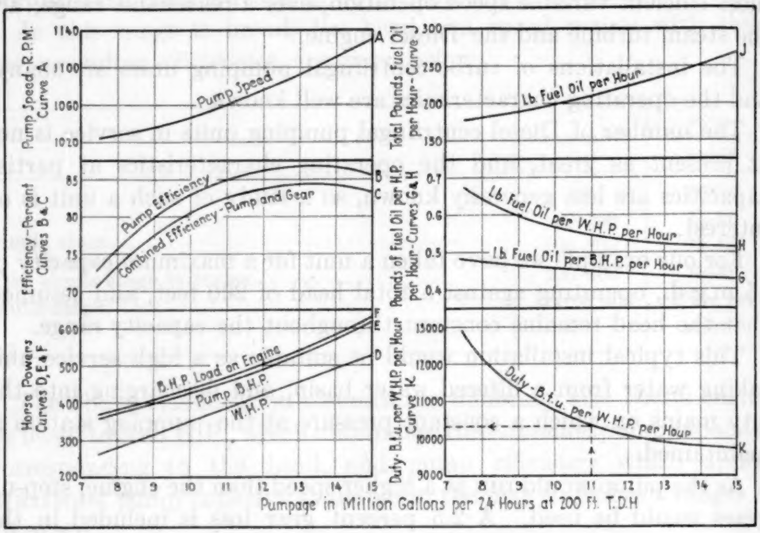

FIG. 1. CHARACTERISTICS OF 7.5 TO 15.0 M.G.D.—200-FOOT T.D.H. DIESEL—CENTRIFUGAL PUMPING UNIT

If the overall efficiency of the *driven unit*, and the fuel consumption of the Diesel engine driver are known, figures 2 and 3 give the corresponding fuel rates and fuel costs. The fuel cost chart is made up of fuel oil at 5 cents per gallon with a correction factor each side of this base price.

For example, assume an overall efficiency of the driven unit as 82.5 percent, and a fuel oil consumption of 0.45 pounds per B.H.P. hour. The figures give for these conditions a "duty" of 10350 B.T.U. per useful horsepower hour, and a fuel oil cost at 5 cents per gallon of 3.65 mills per useful horsepower hour. The conditions taken in this illustration are indicated on figures 2 and 3.

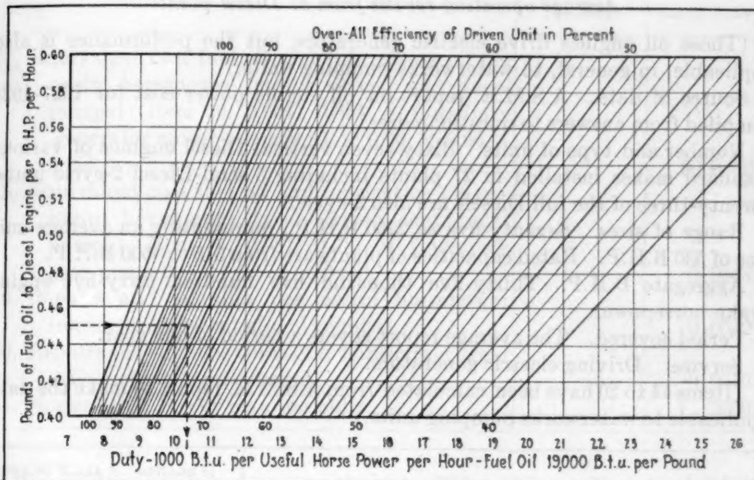

FIG. 2. DUTY IN B.T.U. PER USEFUL H.P. OUTPUT—DIESEL ENGINE DRIVEN UNITS

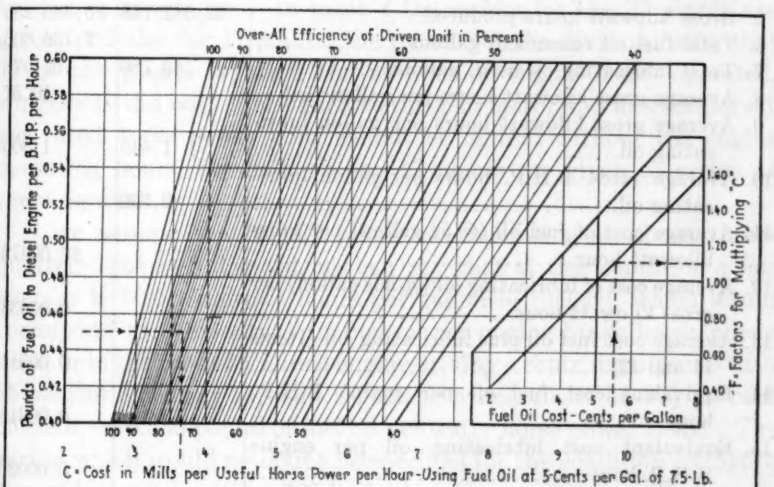

FIG. 3. COST IN MILLS PER USEFUL H.P. OUTPUT—DIESEL ENGINE DRIVEN UNITS

TABLE 1

Average operating results from 27 Diesel plants

(These oil engines drive electric generators, but the performance is also applicable, in general, to waterworks pumping units.)

Source of data. A.S.M.E. report on oil engine power cost for 1927–1928 compiled from answers to questionnaires.

Number and type of units. Sixty-seven vertical Diesel engines of various standard makes installed in 27 plants including 5 semi-Diesel 2-cycle units. Twenty-three of the full Diesels are also 2-cycle.

Range of sizes. Seventy-five to 2250 B.H.P., representing an average unit size of 530 B.H.P. Rated capacities of plants are from 315 to 4500 B.H.P.

Aggregate B.H.P. Thirty-five thousand five hundred sixty-five engine brake horsepower.

Period covered. The average report covers a period of one year.

Service. Driving electric generators.

(Items 14 to 20 have been calculated from A.S.M.E. report to make the data applicable to waterworks pumping units.)

	17 PLANTS	ALL 27 PLANTS
1. Aggregate engine horsepower reported	23,780	35,565
2. Rated horsepower hours reported, per year	128,421,450	
3. Average equivalent operating time, hours per year	5,400	
4. Average running capacity factor, percent	73.5	
5. Gross kilowatt hours produced	63,382,145	75,395,250
6. Total fuel oil consumed, gallons		7,136,806
7. Total lubricating oil used, gallons	43,780	57,978
8. Average gross kilowatt hours per gallon fuel		10.57
9. Average gross kilowatt hours per gallon lubricating oil	1,445	1,300
10. Average rated B.H.P. hours per gallon lubricating oil	2,930	
11. Average cost of fuel oil (@ 5¢ gallon) per gross kilowatt hour		$0.00473
12. Average cost of lubricating oil (@ 50¢ gallon) per gross kilowatt hour		0.00038
13. Average cost fuel oil plus lubricating oil (Items 11 and 12)		0.00511
14. Equivalent cost fuel oil per engine B.H.P. hour		0.00318
15. Equivalent cost lubricating oil per engine B.H.P. hour		0.00026
16. Equivalent cost fuel oil plus lubricating oil (Items 14 and 15)		0.00344

TABLE 1—*Concluded*

	17 PLANTS	ALL 27 PLANTS
17. Equivalent cost fuel oil and lubricating oil per useful horsepower (motor driven centrifugal pumps) (Item 16, 0.654) 0.654 = (auxiliary generator motor pump 0.95 × 0.90 × 0.90 × 0.85)........		$0.00526
18. Equivalent cost fuel oil and lubricating oil per useful horsepower (gear driven centrifugal pumps) (Item 16, 0.787) 0.787 = (auxiliary gear pump 0.95 × 0.975 × 0.85)........		0.00437
19. Repairs and supplies per useful horsepower (motor driven centrifugal pumps)........		0.0012
20. Repairs and supplies per useful horsepower (gear driven centrifugal pumps)........		0.0010
21. Normal B.H.P. per man per shift........		2000

To meet possible comments that the illustrations given in the foregoing are largely theoretical with no established basis, the following figures are presented from the A.S.M.E. report on Oil Engine Power Costs read at Pennsylvania State College in June, 1929. The report covers 27 plants, including 67 vertical engines, direct-connected to electric generators. In table 1 the results for the 27 plants are given, and also for 17 plants, the reason for the division being that 17 of the plants reported the number of engine hours operated, whereas 10 did not. Inasmuch as the load factor and lubricating oil per rated horse power hour cannot be figured without the engine operating hours, the data on the 17 plants are given to arrive at these figures.

If we assume that all 27 plants are operating at about three-quarters load at full speed, we can say that at this condition a fair average is 10.57 kilowatt hours per gallon of fuel oil, which would correspond to 0.464 pound of fuel oil per engine brake horse power hour, or in the case of a Diesel engine driving a centrifugal pump with 85 percent efficiency through a gearing which might be 97½ percent efficient, to 0.560 pound of fuel oil per water horse power hour. The engine which would no doubt be specified for the condition on figure 1 would be not less than 700 brake horse power rating. The condition at 11,000,000 gallons per day on figure 1 is arrived at at 94 percent of full speed and 470 engine horse power, which would correspond to 71.5 percent full load torque. It will be noted that for this condi-

tion the curve gives the 0.545 pound of fuel oil per water horse power per hour. It would indicate that the results shown by figure 4 should be representative of what is obtained the year around.

Interesting comparative actual operating costs are given in table 2.

The present development of the Diesel engine applied to water works service, and the future expansion in its use which seems assured, cannot help but command attention.

TABLE 2

*Average operating cost of steam, electric and Diesel waterworks plants**

For month of May, 1929

TYPE OF PUMPING UNIT	STEAM (CRANK AND FLYWHEEL)	PURCHASED POWER (MOTOR DRIVEN CENTRIFUGAL)	DIESEL (GEARED CENTRIFUGAL)
Million gallons per day (24 hours)	8.17	2.35	2.88
Average total head in feet	316	341	307
Average water horsepower	452	140	155
Efficiency (wire to water)		71.2%	
Cost of coal, electric current or fuel oil	$3.33 (2000 #)	0.0125 (k.w. hr.)	6.7¢ (gal.)
Operating cost per millimeter foot pounds (including labor supplies and power), dollars	0.00818	0.0063	0.00515
Equivalent operating cost per water horsepower hour, dollars	0.0162	0.0125	0.0102

* Data taken from article by A. D. Couch, Mechanical Engineer, Community Water Service Company, published in Hydraulic Engineering, December, 1929.

DISCUSSION

F. G. GORDON[3]: Mr. Hall in his paper has pointed out quite clearly the operating efficiencies which may be expected from a Diesel engine when applied to pumping station loads. One particularly interesting fact brought out by Mr. Hall is the relationship existing between fuel consumption and speed of the Diesel engine.

It may be of interest to those not familiar with Diesel installations to learn of the auxiliaries which are required for a Diesel plant. The auxiliaries for such a plant may be divided into two groups, in much the same fashion as those for a steam plant. In the first group are

[3] Gordon and Bulot, Consulting Engineers, Chicago, Ill.

auxiliaries which are required for any installation; while in the second group are those which may be added to improve efficiency or reduce maintenance costs.

The auxiliaries which are required for every plant include storage space for fuel oil, a hand-operated fuel oil pump, a cooling water supply, fuel oil piping, cooling water piping and exhaust piping. Many of the plants in operation in the United States today include only the auxiliaries outlined.

Additional auxiliaries which may be installed in connection with the handling of the fuel oil include a live steam supply for heating the oil in tank cars, to enable them to be readily unloaded during cold weather; heating coils in the fuel oil tanks, to enable the oil to be pumped easily during cold weather; motor-driven fuel oil pumps; oil meters for measuring the amount of oil used; oil purifiers for removing dirt from the fuel oil; and recording liquid level gauges to show time and rate of usage of fuel oil.

The geographical location of the plant, the quality of the fuel oil used, the amount of storage available, the time of delivery of fuel oil to the plant, the location of fuel oil storage tanks above or below ground, and the extent to which records are desired determine which of the fuel oil auxiliaries are required.

A cooling water supply for Diesel engines used in water works service is of course readily available. Different engine manufacturers specify different quantities of cooling water per brake horse power for the same temperature rise. The maximum quantity required should not exceed eight gallons per horse power per hour under the most unfavorable conditions, and in most cases will be considerably less than that amount. Morrison states that a closed system in which soft water is passed through the engine jacket, recooled in pipe coils and then recirculated, is a desirable auxiliary, if the amount of calcium and magnesium carbonates in the water otherwise available at the station exceeds six grains per gallon. Sulphates are not precipitated as scale at the cooling water temperatures maintained in engine operation. With a closed system it is desirable to have elevated storage for the cooling water. A water meter for measuring the amount of cooling water used is inexpensive and is usually installed.

A great many plants find it economical to increase the engine hours use of their lubricating oil by putting it through a purifier. One of the best purifiers for this purpose is of the centrifuge type. In small plants this purifier can be used for both fuel oil and lubricating oil.

An auxiliary which may be useful in connection with the air supplied to the Diesel engine is an air filter. Air conditions in the vicinity of the air inlet pipe will determine whether such an auxiliary is worth while.

In plants of any size a traveling crane can almost be classed as essential. It facilitates any repair work on the engines, such as removal and replacing of cylinder heads and liners. In smaller installations an overhead trolley which will permit chain blocks to be installed is quite satisfactory, and in a large number of installations portable A-frames are used for repair work.

An exhaust muffler is ordinarily included in the engine contract. With two-cycle engines inlet mufflers are sometimes installed, if it is desired to keep plant noises at a minimum.

A pyrometer for determining exhaust temperatures is not regularly included in the equipment furnished by engine manufacturers, but is of service to the operator.

Indicator mechanism may or may not be furnished with the engine. Its use is similar to that in steam engine practise and when used, permits the operator to check up on the action of the various cylinders of the engine from his indicator cards.

It will be noted that most of the auxiliaries mentioned require no power for their operation. The cooling water system will require a small amount of power during the period the engine is in operation; while motor-driven fuel oil pumps, centrifuges and live steam coils require power only at occasional intervals.

A. D. Couch:[4] At this time I would like to compliment Mr. Rodney D. Hall on his most interesting paper which so ably covers the subject of Diesel engines in water works service. I would like to take this opportunity to discuss further very briefly the two topics which are of equal interest to all of us who are operating Diesel engines. These are lubricating oil and fuel oil.

LUBRICATING OIL

Our Company operates many Diesel engines of different types and descriptions and it can be definitely stated from our experience that lubrication plays a most important part in securing efficient perform-

[4] Mechanical Engineer, Community Water Service Company, New York, N. Y.

ance, keeping the engine in serviceable condition, reducing repair costs, and securing long life from the wearing parts.

The results secured from Diesel engine operation depend on the system used for oiling, on the quality and character of the oil used, and on the methods used for keeping the oil in good condition during service.

The system of oiling is decided on by the builder. Good, reliable, mechanical force-feed oilers are important in getting just the right amount of oil to cylinders. Too much oil is as bad as too little, and it is needed regularly at all times. For the bearings, good results are secured with forced feed or with a good circulation oiling system.

Whatever parts we are considering, lubrication is accomplished by keeping an effective oil film between all moving parts, to keep them from wearing on one another, to give them free motion, and, in the case of cylinders, to prevent unnecessary blow-by of gases.

In the power cylinders, oil films are exposed to hot, burning gases, and are kept from instant burning only by their contact with the water-jacketed cylinder walls. Even so, the film temperatures are very high near the head end of the cylinder. Pressure of the gases is highest when the piston is near this end of the stroke, and this gas pressure back of the rings, particularly the top ring, makes them bear heavily on the oil film, which is already under the weakening influence of heat. This is the reason why wear first appears near the head end. Prevention of wear requires the use of an oil that will still provide a strong film under these high temperatures and pressures; it must be fluid enough to distribute well on the cylinder walls, and must resist the formation of carbon deposits in valves and back of piston rings. The larger the power cylinders, the higher the temperature of the cylinder walls, because their greater thickness separates the film farther from the cooling water.

Cylinder cooling is necessary to prevent temperatures that are destructive to the oil film, and injurious to the materials of construction. Of course, water cooling becomes ineffective when the jackets are clogged with deposits or scale from dirty, hard or salty water. Such a condition must be guarded against by whatever means suits the case—filtering, softening, inspection and cleaning of jackets, etc.

Piston cooling by oil circulation requires the use of an oil that will stand up under the heat, otherwise deposits on the under side of the piston head will interfere with cooling, and damage will result.

Any kind of a black deposit in exhaust ports, on cylinder and pis-

ton heads, and back of piston rings, is generally thought to be a carbon deposit from the lubricating oil. If an unsuitable oil is used, these may be carbon deposits, but if a high quality oil that has proven its correctness for this service is being fed in moderate amounts, it is well to look elsewhere for the cause. This cause may be dirty air, or it may be impure fuel, containing large quantities of incombustible material; or it may be incomplete combustion of the fuel, leaving behind the unburned residues of the fuel. Whatever the cause, such deposits are a menace to the proper action of piston rings, and in turn to the effectiveness of lubricating and sealing oil films.

Bearings lubricated by force feed oiling from a mechanical lubricator can be supplied with a clean oil that will assure safe lubrication. Oil recovered from the crankcase can be filtered and used again if originally of the proper quality.

Circulation oiling is more common for large engines, and is very successful where the right oil is used and steps are taken to keep down the accumulation of impurities in the oil.

Where the engine is single-acting, with the power cylinders open to the crankcase, impurities work in from the cylinder. These may be incombustible matter from the fuel, products of incomplete combustion, dust from dirty air or deposits as a result of incorrect cylinder lubrication. Some of these impurities may be abrasive and cut the bearings. Water may enter through leaky joints in jackets or in some other way.

Water and other impurities constantly circulated with oil tend to cause an emulsion to form, that may clog pipes and strainers. This may prevent oil reaching bearings, and cause their failure.

Even where such impurities cannot enter, the oil may gradually become oxidized by heat and exposure to air. Oil oxidation produces a variety of substances, some soluble in oil, and some insoluble. If they are allowed to accumulate the result is sludge, which deposits in strainers, oil pipes, oil ducts in crankshafts, coolers, and particularly in reservoirs. Moreover, these substances make it easy to produce objectionable emulsions.

These troubles incident to circulation oiling are greatly diminished with the use of a proper oil, and the regular practice of purifying the oil. Settling tanks and filters are useful for this purpose. Centrifuges are equally effective and more rapid in their action.

The main points to consider in selecting the bearing oil are as follows: It should possess great film strength, to resist rupture of the

film under heavy pressure; it should have great durability resulting from chemical stability, which resists any change in the character of the oil during service; it should be able to separate readily from water and other impurities; and it should have the correct body for the service, and still with ample fluidity to flow in the pipes and passages of the system.

On engines where the fuel is injected by air pressure, lubrication of the air compressors has to be considered. Although temperatures are not so high as in power cylinders, there are other difficulties. Moisture in the air being compressed is separated out in the intercoolers. But there are times when some of this is picked up by the air and carried to the next higher stage of the compressor. If the oil is of a kind that is washed away by water, wear is sure to follow. This shows up near the end of the compression stroke in the high pressure cylinders. To overcome this, the oil should be one that has been developed specially for this purpose.

Do not experiment with oil. The manufacturer has done this and will supply lists of approved oils, and in some cases recommend specific brands. The builder's advice should not be ignored. Where there is a choice, it is well to select a good reliable oil manufacturer, who provides the services of experienced lubrication engineers.

Having selected the best oils available for power cylinders and bearings, and for air compressor cylinders, if they are used, the next thing is to give careful attention to correct rates of feed, good condition of piston rings, correct timing of fuel injection valves, impurities in fuel, dust in intake air, cleaning of water jackets, purification of bearing oil and the draining of intercoolers of air compressors. Then you can hope for reliable and efficient performance of the engine and a moderate consumption of lubricating oil, with minimum cost of upkeep.

FUEL OIL

It is exceedingly hard to procure reliable data on fuel oil for several reasons. One of the most important of these is that fuel oils are absolutely dependent upon a number of variables and information which is received today may not hold true six months from today.

Furthermore, the facts as they exist in one locality cannot govern conditions in another. These variables mentioned above are dependent upon the crude, ever changing refinery processes, supply and demand, and a number of others which are of less importance. Con-

sequently, it is impossible to say that the fuel oil problem is solved when a satisfactory fuel is found which is supplied by some local dealer, for unless the oil manufacturer is well versed in Diesel engines, changes can occur in the crude supply and the manufacturing program which renders that same oil which has been supplied, an unsatisfactory product for the operation of the engine, without the supplier or the operator being able to definitely determine why.

There are oils on the West Coast fairly low in gravity which make highly satisfactory Diesel fuels, while an oil might be selected similar in physical characteristics in some other locality which would not give the results which should be obtained.

There are three fundamental items of interest, namely, consistent source of supply, economical price and satisfactory operation. The following procedure should be followed where possible.

Determine the local industrial conditions. From this it can be assumed which will be the most widely and universally distributed fuel to meet requirements of the particular locality. There are certain sections of the country where domestic heating has become so prevalent that a consistent supply of oil is assured which should be satisfactory for the operation of the average Diesel engine from the same source as the domestic fuels are derived. In other localities where a great deal of oil is used for gas manufacture, this could be considered an assurance of a consistent supply of Diesel fuel. These matters are well worth considering.

As is very often the case, the number of Diesel engines in any particular locality, especially rural sections, would not justify the oil supplier in stocking a particular grade of fuel for Diesel operation, and if the engine selected will satisfactorily operate on one of the oils which is in greatest demand, the problem of a consistent supply of fuel is practically solved. Of course, it is well to make this survey before purchasing and installing the engine and at that time buy equipment which would be guaranteed by the manufacturer to operate on the grade of oil which is easily obtainable. It is so often the case that a certain type of engine is purchased and then a search made for the proper oil. It would appear that this is the wrong sequence of events and should be reversed.

In regard to quality, and drawing from our past experience, it may be said that engines should be divided into two general classes, namely, large heavy duty engines and small, moderately speed, small bore and stroke engines. Then the following rules can be used in selecting the proper fuels.

For the former class, fuels should be purchased having a maximum viscosity of 150 seconds when using the Saybolt Universal machine at 100°F. This will give an oil fairly fluid at normal temperatures, which will readily flow into the pumps, and can be cleanly atomized and completely burned.

Conradson carbon, very often called carbon residue, is the next consideration of importance. It is very seldom considered by Diesel engine operators, due mostly to their lack of knowledge on this subject, but it is felt that this is one of the points which greatly affects the life of an engine as high carbon residue results in excessive cylinder liner wear. Three percent should be the maximum limit in this case. While on the subject of wear, of course, ash should be considered and 0.08 percent should be the maximum limit. The items of gravity, flash and sulphur should not be given too great consideration in determining the quality of an oil for Diesel operation. They are bady worn out terms and the only one which is of any importance is the flash. This should be maintained above the legal limit which is as a rule, 150°F. Of course, it is essential to have clean moisture-free oil.

In the latter class, namely, the small, high speed engine, it is felt that the Conradson Carbon should not be over 0.75 percent. Maximum viscosity, 75 seconds Saybolt Universal machine at 100 degrees Fahr. and correspondingly low ash of 0.03 or 0.04 percent are the points of major consideration.

If this procedure is followed in connection with oils, it has been our experience that satisfactory operation of any Diesel engine plant will be assured.

TRAINING OPERATING PERSONNEL FOR SMALL PURIFICATION WORKS[1]

By J. Summie Whitener[2]

The problem of securing and training operating personnel for small purification works confronts almost every small town in every state in the Union. Some towns have solved this problem, whereas the majority are still working on it, and some have not yet realized that they are faced with it. The excellent methods by which North Carolina, through its Bureau of Sanitary Engineering of the State Board of Health, has helped the small towns solve this problem, will be explained. The training of non-technical and technical operators, the placing of small water and sewage purification works in the same town under a single technical operator, and other work that is being done by technical operators, will be discussed. Towns with a population of 10,000 or less are considered as *small towns.*

HISTORY

The Bureau of Sanitary Engineering was established in 1919. The first survey of water purification plants in 1921 showed a total of fifty plants, with one plant technically operated, and the necessity for a wholesale reconstruction and improvement program before much improvement in operation could be expected. This program was successfully carried out by using practically the same methods as have been used in obtaining better plant operation and more technical plant operators.

OBTAINING BETTER PLANT OPERATION

The first step in obtaining better plant operation was the performance of service to municipal officials. Most officials serve for one or two years and in many instances they have no one to advise them as to their responsibilities in matters affecting public health. The Bureau's

[1] Presented before the St. Louis Convention, June 6, 1930.

[2] Assistant Professor of Sanitary Engineering, State College of Agriculture and Engineering, Raleigh, N. C.

engineers sought to advise them as to the extent of their responsibility, acquaint them with public health laws, and help them solve problems affecting public health. In a great many cases the engineers would roll up their sleeves and help repair equipment that was out of order, giving the plant a thorough cleaning, etc. This helped to convince the officials that these engineers knew what they were talking about and that they were willing to help carry out any suggestions that were made. Such tactics tended to educate and make friends of municipal officials from the Mayor down.

Training non-technical operators

The methods used in training all non-technical operators, while generally the same, varied in detail for each town and were applied alike to operators newly employed and those who were considered experienced. In every case an engineer spent from one to two weeks with the plant operator and instructed him in the proper operation of his plant and in the use of such laboratory equipment as had been provided. The plant was thoroughly cleaned and all equipment overhauled. In some cases this took a great deal of diplomacy on account of antagonism of either the operator or the superintendent, or both, as they looked on the engineer with suspicion, treating him as an inspector to be tolerated and got rid of as quickly as possible. In cases of this kind he spent only a few hours at the plant and, before leaving, called on the city officials and offered the services of the Bureau if at any time they were needed. It was then the policy to wait until the town called for help in case of trouble or a sudden emergency. When such a call came an engineer would get on the ground in the shortest possible time, generally in a few hours, and advise the officials what to do and help them to do it. He would stay on the job until the trouble was remedied or the emergency had passed. Then he would usually carry out the program of training the operator and cleaning up the plant before leaving. This method often brought better and the more lasting results because of the service rendered and the friendly relations established.

In other cases, the operator and the superintendent coöperated with the engineer in carrying out the program of training for the operator. Sometimes the superintendent would take advantage of this opportunity to learn more about plant operation himself, and if the plant needed additional equipment or laboratory apparatus, the superintendent would order it if he had the authority, and if not, the engineer

would go with him before his Board and back him up in his request. In every case it was very carefully explained to the officials that all parties concerned were handicapped by the fact that a non-technical operator could not take in all that the engineer was able to teach him.

This period of training was followed up from time to time to make sure that the operator understood all that had been taught him and that he had not fallen by the wayside and was neglecting the plant.

Training inexperienced technical plant operators

When a technical man was employed by a municipality to operate its purification plant, an engineer was detailed for at least a week to operate this plant and gradually break him in, letting him assume more and more responsibility as he was able. The training of technical plant operators was carried out in the same way as that of non-technical operators, except that it took less time. The engineer was able to explain in detail the theory of water purification and plant design and feel that he was being followed and not wasting his time. The making of laboratory tests and their application to the control of operation were not taught in a mechanical and elementary way, as was done with non-technical men, but the significance and application of every test were explained in detail and understood by the technical operator.

When it was felt that the operator could operate the plant properly, he was left for a week or two and then a few more days were spent with him. During the time the engineer was not on the job, the operator knew it advisable to call him back immediately if anything went wrong. In this way, the town was not left to the mercy of an inexperienced operator nor the operator to the mercy of the town. And at no time was the town supplied with unsafe water. This method made lifelong friends of the town officials and the operator, and was well worth the time and money spent.

SECURING TECHNICALLY TRAINED PERSONNEL FOR SMALL PURIFICATION WORKS

Educating the municipalities

The first contact having been made and friendly relations established on a sound basis, the next step was to explain the necessity of technical plant supervision and that such supervision was not only the best possible insurance against unsafe water, but that in almost

every case it resulted in a material decrease in the cost of plant operation. As more technical men were employed, this statement was very satisfactorily proved. In some instances technical men saved as much or more than their year's salary in less than a year's time by reducing operating costs. This was done by the proper and frequent adjustment of chemical dosages controlled by laboratory tests, care and maintenance of plant equipment, etc., thereby cutting down the repair costs and increasing the overall plant efficiency.

Another strong argument was that, by employing a technical man who would make daily chemical and bacteriological laboratory tests and keep records of these tests together with other necessary plant records, the town showed that it was providing the best possible protection for its water consumers against water-borne diseases. Plant records kept by a competent operator have been used in court for the conviction of persons polluting the raw water supply and as evidence to dismiss any suspicions as to the safety of the water supply in case of an epidemic which is later traced to another source.

In small towns it was pointed out that a technical operator with engineering training would be able to serve the town, in addition to his duties as plant operator, in the following ways:

1. As operator in charge of the sewage disposal plant, he could make daily laboratory tests and control the plant operation by them. For the average small town sewage plant this would require but very little additional laboratory equipment to that already in the water plant. Records of sewage plant tests and operation are very valuable to the town in case of damage suits brought by property owners on the stream below the plant. With a properly designed sewage plant and technical operation, it is very hard to prove negligence on the part of the town. This helped to change the almost universal opinion that small sewage plants once built needed no operation and could be forgotten.

2. As milk inspector in both large and small towns that have passed the standard milk ordinance, he would be able to inspect the dairies and test the milk delivered in town. This gives the town a competent man to enforce the provisions of the standard milk ordinance Taken separately, this job would cost the town at least $75.00 per month, but by combining it with the plant operator's job, it requires an increase of only about $25.00 a month in his salary, plus travel allowance to and from the dairies.

3. As assistant to the superintendent of water works, city engineer

or city manager, he could make accurate maps of the water and sewerage system, keep these maps up to date, and solve many small engineering problems that are always coming up and are not large enough to justify the employment of a consulting engineer. This additional service coupled with the reduction in plant operation costs would more than justify his salary.

4. As superintendent of water works in towns that had enough plant capacity and clear water storage so that the plant could be operated a few hours each day or every other day and supply the demand. The salary for the combined job has in some cases been less than that of a non-technical superintendent.

5. As a final argument, it is pointed out that a non-technical man of the type usually employed as operator, such as garage mechanic, one familiar with steam engines, pumps, etc., would cost the town at least $100.00 per month, but not having the education and basis training, he could not take in all the Bureau's engineers might teach him and, therefore, could go only so far in the field of plant operation. On the other hand, a technical man can be secured for a salary around $125.00 and would be able to develop initiative of his own and become of very much greater value to the town.

Locating a technically trained man

It was quite natural that, after having convinced a municipality of its need for a technically trained man, the question arose: "Do you know where we can get a good man?" or "Can you get us a good man?" The answer was that not *one*, but *several* men would be located who could be recommended on the basis of their training and experience and that it would then be up to the town to employ the one that suited them best. When a man is employed, an engineer spends whatever time is necessary in teaching him how to operate the plant and check up on his work from time to time to see that the town is getting the type of plant operation it is paying for. If it is found that this is not the case, the engineer will advise the town and recommend that it get another man.

In the first few cases, men with training and experience in plant operation were secured from other states. These men were for the larger towns that could afford to pay them enough to justify a change. The Bureau then turned to the list of graduates from the North Carolina State College of Agriculture and Engineering, and from the University of North Carolina and found that neither college had a

curriculum in sanitary engineering, but that graduates in civil engineering or chemistry could be used and that positions as plants operators were attractive to them. In nearly every case, the starting salary was $125.00 per month. The supply has been kept ahead of the demand between periods of graduation by recruiting men who had started out in other branches of engineering or chemistry, having become dissatisfied and desired to make a change.

MAINTAINING TECHNICALLY TRAINED MEN AS PLANT OPERATORS

Relation of plant operator to municipality and to bureau of engineering of the State Board of Health

The operator, as stated before, is employed and paid by the town. It was explained to him that his recommendation was based on his technical training and on the belief in his ability to do the work. He understands that he is to be helped in very possible way and it is assumed that he will be conscientious and take an interest in his work. He also understands that if he becomes careless or lazy and does not operate the plant properly, he is endangering public health, and drawing a salary which he does not deserve, and that the town will be acquainted with the facts and advised to employ another man.

Monthly reports

Monthly report blanks are furnished to both water purification and sewage plant operators. These reports have columns for all necessary plant operation data, cost data and results of chemical and bacteriological laboratory tests. These data are entered on the report daily and at the end of the month the report is totalled and averaged. This report is kept in the plant and two ink copies are made, one for the superintendent of water works or sewage works and one is sent to the Bureau of Sanitary Engineering at Raleigh. When these reports reach the Bureau's office, they are carefully checked for mistakes in calculation, poor plant efficiency, or improper operation. Such errors are called to the operator's attention by letter or by a visit from one of the engineers.

Field inspections

Routine inspections are now made of each plant once a month. The number of inspections made of any one plant varies according to the number of engineers available and to the character of the plant

operation. In making an inspection, if the engineer finds anything wrong, he calls it to the attention of the plant operator and discusses with him the best method of correcting the trouble. In case additional equipment is needed, he goes with the operator to the superintendent and backs up the operator's request. If necessary, an official letter to the town Board is written recommending the additional equipment. In this way the operator feels that an inspection of his plant is made not for the purpose of criticising his operation, but to make suggestions that might improve the operation and help him solve any problems that have been troubling him. This method, besides giving a true picture of the operation of each plant, keeps the engineers on very friendly terms with the operators and superintendents and promotes the best kind of coöperation.

Investigation and research

In case serious trouble is reported by an operator, an engineer is detailed to spend whatever time is necessary for investigation and research, to locate the source of trouble and to help the operator work out some method of correcting it. Recently the manufacturers in a small town complained to the Bureau about the excessive scale formed in boilers using water from the town purification plant. This plant did not have a technically trained operator and the town officials had been perfectly satisfied until they were rudely awakened by the manufacturers. Just at this time the plant operator was accidentally killed and the town called for assistance. An engineer was sent to operate the plant and to locate the cause of the boiler scale. It was found that the scale was caused by improper adjustment of chemical dosages at the plant and a recommendation for the employment of a technical operator was acted on at once. By operating this town's plant for two weeks, the manufacturers were given relief from excessive boiler scale and convinced of the fact that they needed a technical operator.

Advancement to better positions

In the case just mentioned, the technical operator had been running a plant in a smaller town for about four months, at a salary of $125.00 per month. Prior to that, he had been in a city engineer's office making $150.00 per month, but saw no chance for advancement and decided to change to sanitary engineering. The second town paid him $150.00 per month, so in four months he had changed from one

branch of engineering to another and was receiving the same salary. Since then, he has accepted the position as plant operator in a larger town and is in line for the position of superintendent of water works. This is a typical case and is used as a very good argument in getting technical men to accept positions as plant operators.

Advancement in any case depends on the ability, initiative and conscientiousness of a plant operator. When an opening occurs in one of the larger plants, an operator with experience at a smaller plant is usually given the position and in some cases three or four men are advanced to better jobs with more salary, and an inexperienced technical man is started in on the smallest plant.

Before recommending an operator already employed by one town to another town, the officials in the first town are always consulted and advised of the proposed recommendation of their operator for employment by another town. If the operator is receiving the maximum salary the town is able to pay and the second town is willing to pay more, the change is generally made, and the first town employs another operator with less experience at a smaller salary. If the operator is not receiving the maximum, his salary is frequently raised by the first town in order to keep him. Operators have often had their salaries increased without knowing until afterward that a recommendation had been contemplated. The Bureau in all cases is governed by what is fair to both the town and its operator and all parties concerned have realized that it was interested in securing the best possible plant operation for every town in the cause of public health.

The Bureau has had a great deal of trouble in keeping the personnel of its own organization because the larger towns, realizing the type of training its engineers receive, are willing to pay them more as plant operators than they receive as engineers. It has lost one man to another State because that State doubled his salary, another to the North Carolina State College and one to the University of North Carolina. Both institutions now have courses in sanitary engineering, and the two men became professors of sanitary engineering at these colleges. When a man leaves the organization to go with a town or a college, the Bureau does not consider that it has lost a man, but rather that another good technically trained operator or college professor has been released who knows its policy and will help the State improve its public health.

Value of the North Carolina Section of the American Water Works Association

The North Carolina section of the American Water Works Association has been the largest contributing factor in securing and maintaining technical supervision of water purification and sewage disposal plants. A majority of the members are water works superintendents and plant operators. Those superintendents and operators who are not members know that they are welcome to attend all meetings. That they do attend is proved by the fact that the number attending is always much larger than the membership.

A separate conference of water purification plant operators was formerly held at the same time as the Section meeting. Separate sessions were held because some of the older superintendents did not care to listen to long detailed technical discussions of filter plant problems. In 1928, the Section voted to abolish this conference and to have all papers included in the regular section programs, because it was found that the attendance at these conferences was greater than at the regular section sessions. This was due to the increased number of technically trained superintendents and operators and to the changed viewpoint of the non-technical superintendents and operators.

RESULTS

The training of technical and non-technical plant operators has caused a general increase in plant efficiency and a general decrease in the total cost of filtration. Their better understanding of plant operation has helped increase the factor of safety against water-borne diseases. By the proper control of filtration with laboratory tests, plant effluents with a B. coli index of zero are becoming common. Secondary lime treatment for red water control has become standard practice and prechlorination is being used in a number of plants to good advantage.

In one instance a technical operator worked out a treatment process for highly colored water. This process consisted of a primary dosage of chlorinated copperas and a secondary dosage of either sodium aluminate, or alum and lime added simultaneously. Another technical operator increased the length of filter runs, lowered the cost of operation and turned out a better effluent, by the chlorination of coagulated water.

Of the 78 municipal water purification plants in the state, 63 are in

small towns and 28 of these plants are operated by technical men. Twelve of the 15 plants in large towns are technically operated. Three out of 5 institutional plants are operated by technical men. One town with a population of 1,147 has a technical operator who serves as superintendent of water works, looks after the sewer system, and operates the disposal plant.

Sewage plants are better operated because more of them are under the supervision of the water plant operator. More complete and accurate reports of the operation of both water and sewage plants are being kept. These reports are valuable to the individual towns and when compiled into yearly State reports by the Bureau, they become of even more value to the State as a whole.

The municipalities have been educated to the point where they realize the value of technically trained men as operators. This realization of their value has increased the demand for technical operators. Because it was found that graduates in civil engineering or chemistry were not properly fitted for sanitary engineering work, State College and the University have added sanitary engineering to their courses of instruction. State College now has a four year course in sanitary engineering and courses for graduate students.

This course is designed to prepare graduates for positions as technical operators to supply the demands of the municipalities.

Coöperation between the administrative agencies and educational institutions of the State has materially aided the rapid progress made in sanitary engineering and public health work. Such coöperation must be practiced in any state that expects to make much progress.

DISCUSSION

Abel Wolman:[3] I should like to comment very briefly on this paper because it appears to me to have a two-fold aspect. One is that it refers to the very difficult problem of the small town plant, a problem which ordinarily does not receive a great amount of attention, particularly in large scale meetings and discussions; and, secondly, because in the development of a plant in a small town, it is my belief, after observing the operations in the state of North Carolina, that if they have not developed one of the best plans, they at least have developed one that approaches as near to a degree of perfection as is practicable in promoting small town operation. The features which

[3] Chief Engineer, State Department of Health, Baltimore, Md.

Mr. Whitener has pointed out in the development of that plan I think are worth emphasis, because Mr. Miller, who I believe is largely responsible for the development of the undertaking, has made use of practically all the psychological and organizational facilities which it is possible for a state to use and has done it so successfully that it has marked a method which a number of other states have applied, either in modification or in adjustment, to their particular local requirements. He has recognized early in the career of the State Board of Health of North Carolina that operation of the plant is really the important link in a chain of protection. Most of us would put that link perhaps as the most important one, because the best designed and constructed plant has relatively no usefulness in the hands of a non-technical, inefficient operator. On the other hand, a poorly designed and constructed plant does marvels in a number of states where the attitude, understanding and coöperation of the local superintendent are up to the maximum degree.

The important thing that I think Mr. Miller has done is, first of all, in recognition of the supreme advantage of continuity of service. He has managed to sell his community on that outstanding advantage, that it is desirable, if not to continue the same man, certainly to continue the same degree of service at all times in communities under ten thousand population. A second practical thing that he has recognized is that, if the small town is not in a position to pay adequately for a high degree of service, it can do so if it consolidates a number of the small town duties. That, in itself, is a contribution, in the recognition of the fact that, if you cannot pay sufficiently for water duties in a town as small as one thousand, you certainly can pay adequately if you combine the duties of control of sewage collection and treatment, and if, in addition, as in some instances, you add the supervision of other public health activities, such as inspection of milk. In most instances, of course, all of us recognize that none of the consolidations are very useful unless a man can afford to live on what he gets. Mr. Miller has recognized this difficulty. He has insisted on fair compensation, a living wage and a continuity in office.

Another item which appeals to me is the assurance that he has given for the promotion, either from town to town or within the town, so that there is some incentive for the man to do his job well. In the North Carolina plan, I happen to know, when a shift occurs it usually means a shift in about ten other communities in the upward direction, all of which makes it possible for a man who is interested and perhaps

young and intelligent to move forward as rapidly as his enterprise shows he can move forward. The amount of loyalty in that state is great. The men within the bureau and the men in operation of their communities speak of their occupations with a great deal of pride.

Lastly, of course, none of this could have been possible without the public understanding, that is, an understanding on the part of the community that many of these things are not only necessary and desirable, but that they are easy of accomplishment. There are two other items, which, of course, are not new in North Carolina, but again have been developed to a high degree of satisfaction. These are the maximum use and coöperation of state universities and a maximum use of the local Section of the American Water Works Association. The universities have shown their real interest to the extent of not only supplying the necessary practice, but going out of their way to train people for tasks which most universities either ignore or are not particularly interested in. Perhaps one of the outstanding deficiencies in university training is to get an equipment for the type of man who can carry on a highly specialized task and do it well. A good many of the state universities have not yet recognized that there is a demand for that kind of person. The development of the Section of the American Water Works Association is to the advantage of the state. It is one of the most active of the Sections in this country and all of the water works men are looking to it for inspiration and help.

In summary, my only comment on the plan is that it rests necessarily upon the personality of the Director of the Bureau of Sanitary Engineering and his field forces. This again I think ought to be emphasized, because the whole structure falls if either he or his group in direct contact with the public fails to give service, not service in the common parlance of the term, but real service, as Mr. Whitener has put it, taking off your coat and finding out what is wrong with coagulation and a valve or anything else and doing a little bit of cleaning around the plant. Those of us who have had opportunity to see a good many small plants, and recognize the combination of small filtration plant, county jail and parking place for stray electric lights and so on, realize that very little can be done unless the local superintendent has some pride in his undertaking. I think Mr. Whitener does very well to point out that to mere inspectors this form of state coöperative work means relatively little.

H. E. Miller:[4] In this excellent paper the author has very comprehensively outlined North Carolina's program of securing the employment of technically trained personnel and their subsequent training and development. He speaks with an authoritative knowledge of his subject because he is a product of the system, having served as an operator, as an assistant engineer of the State Board of Health in the development of operators, and is now engaged in the sanitary engineering instruction of students.

The public health agencies of most states have established programs for the improvement of water purification plant safety, considered best suited to their respective states. It is believed, however, that the program just outlined differs materially, in the means of attaining the objective. This is one of the times when necessity is the "mother of invention."

The program is founded upon certain fundamental considerations, among which are:

1. The unit value of life in a small town is equal to the unit value of life in a large town or city. There is, therefore, no "dual standard" of water supply safety.

2. This is an economic age and therefore any public health enterprise that succeeds must be so conducted as to yield a visible economic return.

3. Mere "inspection" is a useless waste of the public funds and a nuisance to municipal officials and employees.

4. Law and regulations are most effectively observed by those who find it to their advantage to do so.

5. When the cloth does not fit the pattern, adjust the pattern or cloth, or both, if necessary.

At a time when there were not men locally available equipped with a proper knowledge of water purification the inauguration of technically supervised operations with adequate laboratory control as a universal practice in the State was undertaken. Since the plants were small the cost of suitably trained men from other states was prohibitive.

By being forced to take raw material locally available within permissible salary range, there has been developed a corps of men in municipal employment which meets the needs of the State, not only in

[4] Chief Engineer, Bureau of Sanitary Engineering, State Board of Health, Raleigh, N. C.

water purification plant operation, but in the field of sanitary engineering in its broader phases. From plant operation the activities of engineers so employed are being expanded into other services to the mutual advantage of the municipalities and the engineers so employed.

Municipal officials have showed a ready interest because it is a good business proposition. Not only can plants be operated more efficiently under proper technical supervision, but the small town can make money by trading the opportunity for practical experience to the engineering graduate for the scientific knowledge he can utilize for the town. Plant operation is the kindergarten of sanitary engineering, and serves to give the graduate engineer an effective grounding in the practical application of the fundamental principles holding the same relationship to the future development of the engineer as hospital interneship serves to the development of a physician from a student who has studied medicine.

The educational institutions, both the State University and the State College of Agriculture and Engineering, have coöperated thoroughly in undertaking to adjust their courses so as to provide the most suitable training of students.

The North Carolina Section of the American Water Works Association has been a means of developing these operators and has been a constant stimulation. It has also brought to the attention of all the superintendents and demonstrated to them the advantage of practical application of scientific principles in routine operation.

The practice of developing inexperienced, but suitably trained men, is slow, but is the only way that the principle of technically supervised operations can be extended to small plants on a state wide basis. Finally, through this system, better qualified men are available for the larger plants, and through the progression from smaller to larger plants, merit is rewarded, and a suitable man is always available for vacancies which occur in any class of plant.

Thomas R. Lathrop:[5] The training of water purification plant personnel has developed along a much different line in Ohio than in North Carolina. This has been due largely to the authority vested in the State Department of Health bylaws relating to the operation of public water works plants. The geographical distribution of our larger cities with relation to their proximity to smaller communities

[5] Assistant Engineer, State Department of Health, Columbus, O.

has also been a factor in the method which has developed in handling this problem in our state.

In 1908 the State Legislature appointed a committee to make a study of the water supplies of the state and, following the report of this committee, a law was passed authorizing the commissioner of health to order the managing officers of any water works which failed to produce a satisfactory effluent "to appoint and pay the salary of a competent person to be approved by the commissioner of health to take charge of and operate such works as to secure the results demanded by the commissioner of health."

Following the Salem, Ohio, typhoid fever epidemic in 1920 another law was passed which is somewhat broader in scope, in that it is now not necessary to wait until a water supply is found to be of unsatisfactory quality before proper operation is provided. The law is as follows: "For the purpose of controlling the sanitary quality of public water supplies, every city, village or other subdivision or district, public institution, public water supply, or water works system shall have analyses made at such intervals and in such manner as may be ordered by the State Department of Health, and records of the results of such analyses shall be maintained and reported as required by the said department."

Almost without exception the larger cities have willingly employed technically trained men to take charge of their water treatment plants. The type of operation obtained conforms to standard practice throughout the country.

At the small water purification plants an endeavor is made to keep up the same standard as at the larger plants. That is, daily analyses are made at practically all of our purification plants. This has been done without recourse to law. It has been accomplished largely by engineers of the department selling the idea of safe water to the village and city officials.

In very few instances in our state have the State Department of Health engineers undertaken to train operating personnel at the small plants. Training for these operators has been secured by the employment of a filtration plant superintendent from a nearby city. He is employed by the village on a part time basis and his duties comprise supervising control over the plant. He visits the small plant at frequent intervals and when necessary to instruct a new operator considerable time may be spent at the small plant. In some cases a new man who is to be placed in charge of a plant spends a week or two

at the plant operated by the supervisor. While there he learns how to make routine bacteriological and chemical tests which are necessary for the proper control of his plant. He learns also the details of plant operation so that when he begins operating his own plant he has a good general knowledge of what is expected of him.

As a rule the small plant operator has a laboratory where he makes chemical determinations and fermentation tests for B. coli. These tests are made daily and a minimum of laboratory equipment is required. Media are usually supplied by the supervisor.

At weekly intervals the supervising chemist makes an inspection of the plant and makes bacteriological and chemical analyses. At times of his visits he looks over the results obtained by the operator and makes recommendations for improvements. His work also includes that of making reports of the operation of the plant to the State Department of Health.

It has been the experience that most operators take an interest in learning to make routine bacteriological tests and in changing the water treatment in accordance with their findings. In a few cases this has not been so. In other cases some of our non-technical operators have studied and taken instructions under the direction of the supervisor so that they have been able to satisfy the State Department of Health that they have sufficient qualifications to operate their plants without supervision. Usually some contact with the supervisor is retained. This varies with conditions. At a few plants the supervising chemist is a supervisor in name only. His duty then is that of analyst. He makes check analyses of the water at weekly, bi-weekly or monthly intervals. This arrangement is permitted only when the operator is thoroughly qualified to operate his plant without immediate technical direction. The check analyses are made to satisfy the public that the best possible protection for the water supply is being secured. Very often there is a feeling on the part of the public that the bacteriological results of the non-technical man are not to be relied upon.

One of the most important points for the supervisor to remember is that of making the proper contacts with the village officials. It is just as important for him to call upon these officials and report his findings as it is to call at the purification plant, in order that the officials do not get the idea that they are sending out a sizeable check every month and getting nothing in return. In other words, the supervisor must continue to sell his services.

A minimum of training of operating personnel for small water purification plants has, therefore, fallen on the engineers of the State Health Department. On them has devolved the task of showing the village officials the advantages to be gained by employing technically trained supervisors for the instruction and direction of the operators.

The system of having the operation of the small water purification plants under direction of a technically trained chemist has worked out very well in our state. It has had the advantage of giving the chemists work outside of their own plants where the experience gained is valuable and the extra remuneration has tended to keep them from leaving the water works field.

E. S. Tisdale:[6] North Carolina as a state, has been one of the leaders in the field of producing and keeping on the job satisfactory, capable, trustworthy filtration plant operators. This is reflected in the rapid progress the State has made in securing safe public water supplies with the constant reduction in the typhoid fever death rate. The State Health Department has succeeded in this vitally important field of purifying river water used for drinkng purposes because it is linked up closely with the University and State College. The same principles and high ideals of service are instilled into the sanitary engineering students at the State College and at the University in North Carolina, which have been developed and nurtured in the sanitary engineering division of the State Health Department for the past eleven years by the present director. North Carolina is solving the problem of supplying capable, trained personnel for new water purification systems by actually producing these trained men from her own citizens. Other states would do well to follow her example and it might be worth while to compare the different states of the country in this respect and note how closely the wheels of instruction at the colleges mesh with the gears of practical application of the principles of water purification at filter plants about the State to produce safe public water supplies.

Our neighboring State of Ohio typifies another example of securing competent operation of small water purification works. Here to a greater extent than in North Carolina the supervisory plan is followed by utilizing the chief chemist or superintendent of filtration of a large city plant to cover several smaller cities nearby, lending super-

[6] Director, Division of Sanitary Engineering, State Department of Health, Charleston, W. Va.

visory assistance to the men in charge of the filter plants. According to this plan the State Health Department undertakes to secure the part time services of this supervisory chemist, who is a well trained sanitary engineer with extensive experience along chemical, bacteriological and water purification lines. The laboratory is maintained at the central city and is completely equipped to study any type of water purification problem which may arise. Under the chemist's guidance the small filtration plant is operated. He outlines the necessary control tests for routine operation of the plant. Frequently, the supervising engineer has media prepared and sent out from the central station. Detailed records are kept and under this system the small filtration plant can operate successfully without a highly trained man in change. Periodic inspection visits are made to check up on this operator and see whether instructions are being carried out faithfully to secure the best efficiency from the plant with economical use of chemicals to produce safe water.

Here then are two different types of systems, the former raising the product from the ground up by college training—a relatively long process, the latter securing the best possible applicant for filter plant superintendent and placing this man under definite supervision by a well trained chemist and bacteriologist. Both systems have been used to advantage in West Virginia since the present director took charge of the sanitary engineering work ten years ago. The new president of West Virginia University has taken the slogan, "Build the University into the Life of the State." The State Health Department is coöperating closely with the Professor of Sanitary Engineering, whose graduate students are now taking their places in the State Health Department organization, in the various full time county health organizations, and as superintendents of water filtration plants over the State. Such a practice reacts favorably in two ways:

1. The students feel that there will be a place waiting for them when they complete their college work satisfactorily and get a vision of being of real service to their State.

2. The professors at the University in the fields of sanitary engineering, bacteriology and biology are kept in close touch with new developments along water purification lines of the State and they are enabled to use the new projects in their educational work.

Coöperative conferences and short schools on water purification which are held annually have become quite popular throughout this country. The West Virginia State Health Department, coöperating

closely with the State University, started four years ago such coöperative work. This has resulted in better training for the operators in charge of water filtration plants and a spirit of loyalty has developed which would probably not have come about in any other way.

The principle mentioned by Mr. Whitener of extending the field of work of the filtration plant superintendent in a small city to cover the operation of the sewage disposal plants, daily inspection and the bacteriological examination of milk samples, supervision of public swimming pools and in fact making this man "Supervisor of Sanitation" for the community is a sound one and is a principle which might well be adopted by many small cities. Such a plan will have the effect of keeping the man himself better satisfied with his work, busy with various types of problems and he will produce more so that he can receive larger financial returns from the community served.

When the man in charge of a water filtration plant feels that he has become an essential part of the public health machinery of the State by being closely associated with and responsible to the State Health Department in his work, he becomes a loyal and responsible and enthusiastic worker for safe water. With the development of this sort of individual we will have a duplication through the State of the enviable record now enjoyed by Clarksburg, West Virginia, where since 1911 when the water filtration plant was started, not a drop of unsafe water has passed into the city mains even though a polluted surface stream is the source of public water supply.

This is the goal to hold out to the new operators of water purification plants whether they are being trained by the college system, as established in North Carolina, or by the apprentice system as successfully used in Ohio to keep well trained modern filtration plants operating to the best advantage.

SUCCESSFUL SUPERCHLORINATION AND DECHLORINATION FOR MEDICINAL TASTE OF A WELL SUPPLY, JAMAICA, N. Y.[1]

By Frank E. Hale[2]

The success of superchlorination followed by dechlorination in preventing medicinal taste in the present instance is of particular interest for several reasons: first, in that it has been applied to a system of wells, second, that the time of contact with the chlorine has been very short and third, that it has been carried out for eight months without complaint under the regular pumping station force without technical supervision, other than could be given about once a month by our Laboratory Division.

The arrangement and relationship of the different units are shown in figure 1. Wells 6-B, 6-A, and 6 are electrically operated wells of the Layne type in which the sand in a large area at the bottom has been pumped out and replaced by gravel introduced between the well and the casing. These wells yield from 0.75 to 1.25 m.g.d., depending upon conditions, particularly resistance caused by height of water in the receiving well. In front of the station is a system of old style wells operated by the steam pump designated "Union pump." These old wells and well 6-B contain appreciable amounts of iron (1 to 2 p.p.m.), wells 6 and 6-A are low in iron (less than 0.5 p.p.m.), and all of the wells have shown presence of manganese as indicated by deposit on the glass syphon tubes of chlorine machines. Three years ago crenothrix caused a musty taste in a portion of the distribution system temporarily supplied from this station and was controlled by chlorination and blowing of the mains. Two years ago it was noted that crenothrix had developed in the wells, connecting mains and distribution system and was controlled by application of about 0.5 p.p.m.

[1] Presented before the Water Purification Division, the St. Louis Convention, June 4, 1930.

[2] Director of Laboratories, Department of Water Supply, Gas and Electricity, New York, N. Y.

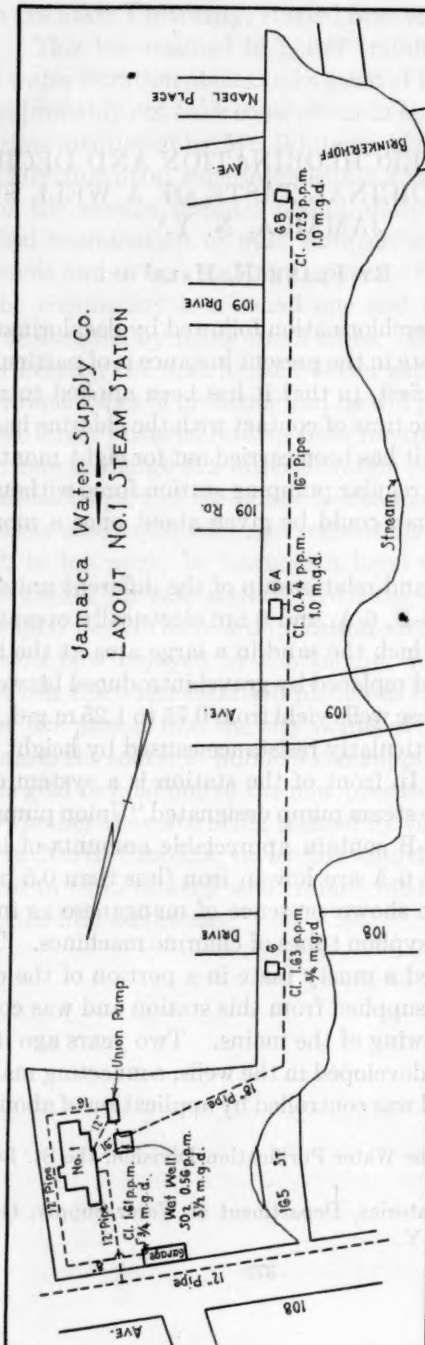
Jamaica Water Supply Co.
LAYOUT NO. 1 STEAM STATION
NADEL PLACE
BRINKERHOFF
AVE
6B
Cl. 0.23 p.p.m.
1.0 m.g.d.
109 DRIVE
16" Pipe
109 Rd.
Stream
6A
Cl. 0.44 p.p.m.
1.0 m.g.d.
109
AVE
108
DRIVE
6
Cl. 1.63 p.p.m.
3¾ m.g.d.
Union Pump
18" Pipe
165
St.
No. 1
Wet Well
Cl. 0.56 p.p.m.
3½ m.g.d.
Cl. 1.61 p.p.m.
3¾ m.g.d.
12" Pipe
Garage
12" Pipe
108
AVE.

Fig. 1

chlorine and blowing of the mains. Thereafter chlorine was continuously applied in small dosage at wells 6-B and 6-A to keep the 16-inch main to the receiving well free from the growth. Owing to the building of a large sewer through this section, although there was no bacteriological or chemical evidence of contamination, it was decided to chlorinate the main pumping station water continuously against any contingency.

In November, 1928, following chlorination of the entire station water, complaints of taste became frequent. Personal inspection disclosed that the taste was of medicinal character and due to chlorination. Samples of water were taken from each of the electric wells and from the Union pump and sent to the laboratory for examination. These were tested with varying doses of chlorine, absorption of chlorine determined and resultant taste. It was ascertained that wells 6-B and 6-A did not develop any medicinal taste with chlorine, but well 6 and Union wells developed a strong taste, with the Union wells the worse. There was no taste without chlorine except the taste of iron in the sources in which this was high. This indicated some organic drainage reaching the northern area of the territory.

There was considerable time involved in learning the cause of the trouble due to the fact that wells 6-B and 6-A were pumped during the day and the water from these wells caused no taste. In late afternoon and evening well 6 and Union wells would be added to meet peak demands and complaints were occasioned by the water supplied in the evening or early morning. Our first thought was that crenothrix was dislodged by the additional flow, but samples from hydrants on the distribution system failed to show any of these growths.

Samples of coke, ashes, and coal (since a certain amount of these were exposed to weather upon the grounds) were extracted with water which was chlorinated and tasted, but without results. Inspection of the drainage territory revealed no apparent cause except a heavy continuous leakage of gasoline from a storage tank at a new garage about $\frac{3}{4}$ mile distant and in the right direction. The gas was so abundant that it was dangerous to enter the water meter vault situated in the building. This garage was built in 1927 when the first complaints were received, but as the station was shut down for repairs for a considerable period of time and put into service again in 1928 it was not until the latter year that it became urgent to discover the cause of the trouble. Some time in the fall of 1929 the gasoline leak was stopped and on March 5, 1930, by tests it was determined that

whatever caused the taste in the water supply was no longer present. In fact the treated water at the station had been without a trace of medicinal taste from December to March.

In order to ascertain whether gasoline itself would give taste when combined with chlorine, one drop of gasoline was added to 3 liters of the well water and in this amount a strong gasoline or kerosene odor was noticeable. One cubic centimeter of this gasolined water was then added to another 3 liters of the well water and then 1 cc. additional up to 5 cc. and then enough to make 10 cc. Samples of these various dilutions were treated with 0.45 p.p.m. chlorine, but no medicinal taste was developed, nor in fact any taste except the lowest dilution in which only the taste of kerosene was noted. Expressed in parts per million these results were as shown in Table 1.

TABLE 1

GASOLINE DILUTION	CHLORINE	TASTE
p.p.m.	*p.p.m.*	
6	—	Kerosene
0.002	0.45	No taste or odor
0.004	0.45	No taste or odor
0.006	0.45	No taste or odor
0.008	0.45	No taste or odor
0.010	0.45	No taste or odor
0.020	0.45	Kerosene

However, gasoline could extract tarry constituents from pavements or organic matters from the ground particularly in a region incompletely sewered which might explain the medicinal taste with chlorine.

Various laboratory tests were made on samples from the wells causing the trouble. It was found that the taste was caused undoubtedly by an organic substance, that excess chlorine up to 2.25 p.p.m. did not destroy the taste once formed, although it would lessen it, nor would such a dosage entirely prevent the taste. Prevention was accomplished by boiling, by oxidation of the organic matter before chlorination, such as by hydrogen peroxide, by air on long standing (several days), partially by aeration, also by addition of 0.2 p.p.m. ammonia previous to addition of 0.4 p.p.m. chlorine, in the case of No. 6 well but not the Union wells. However, 0.3 p.p.m. ammonia with the same dose of chlorine failed to prevent the taste, indicating a rather close regulation of ammonia as possibly necessary. In the

TABLE 2

Experiments with chlorination and taste, Jamaica water supply, December 28 and 29, 1928

	WELL NO. 6	UNION WELLS
Iron	0.70 p.p.m.	2.40 p.p.m.
Taste untreated	Iron	Iron
Residual chlorine, treated with 0.4 p.p.m. Cl	0.10 p.p.m.	0.03 p.p.m.
Absorbed chlorine, treated with 0.4 p.p.m. Cl	0.30 p.p.m.	0.37 p.p.m.
Taste after treatment with 0.4 p.p.m. Cl	Medicinal	Strong medicinal
Taste treated with 0.2 p.p.m. NH_3 then 0.4 p.p.m. Cl	None	Strong medicinal
Taste treated with 0.3 p.p.m. NH_3 then 0.4 p.p.m. Cl	Slight medicinal	Strong medicinal
Taste treated with 0.4 p.p.m. Cl then 0.2 p.p.m. NH_3	Slight medicinal	Strong medicinal
Taste mixture 2/3 (6B) and 1/3 (6) treated with 0.4 p.p.m. Cl	None	
Taste mixture 2/3 (6B) and 1/3 (Union) treated with 0.4 p.p.m. Cl		Strong medicinal
Taste treated with peroxide, 500 p.p.m. (1 drop: 100 cc.) then 0.4 p.p.m. Cl	None	None
Taste after standing over night then 0.4 p.p.m. Cl	None	Reduced medicinal
Taste after standing 5 days then 0.4 p.p.m. Cl	None	None
Taste after shaking one-half minute in bottle then 0.4 p.p.m. Cl		Strong medicinal
Taste after shaking two minutes in bottle then 0.4 p.p.m. Cl	None	
Taste after aerating five minutes with air then 0.4 p.p.m. Cl		Reduced medicinal

laboratory, admixture of equal amounts of water from 6-B, 6-A and 6 so diluted the organic matter of well 6 that chlorination produced no taste, but when tried at the station complaints immediately re-

TABLE 3

Experiments with chlorination and taste, Jamaica water supply, December 10, 1928

(Results in p.p.m.)

10 MINUTES*			20 MINUTES*			30 MINUTES*			IRON	TASTE
Dose	Resid-ual	Ab-sorbed	Dose	Resid-ual	Ab-sorbed	Dose	Resid-ual	Ab-sorbed		
Well 6-A (15 minutes pumping)										
0.45	0.12	0.33	0.45	0.12	0.33	0.45	0.12	0.33	0.15	None
0.90	0.35	0.55	0.90	0.35	0.55	0.90	0.32	0.58		
Well 6-A (75 minutes pumping)										
0.45	0.12	0.33	0.45	0.15	0.30	0.45	0.15	0.30	0.45	None
0.90	0.33	0.57	0.90	0.30	0.60	0.90	0.33	0.57		
Well 6-B (15 minutes pumping)										
0.45	0.05	0.40	0.45	0.05	0.40	0.45	0.05	0.40	0.95	None
0.90	0.22	0.68	0.90	0.22	0.68	0.90	0.25	0.65		
Well 6-B† (75 minutes pumping)										
0.45	0.09	0.36	0.45	0.10	0.35	0.45	0.09	0.36	1.40	None
0.90	0.25	0.65	0.90	0.25	0.65	0.90	0.25	0.65		
Union Pump (15 minutes pumping)										
0.45	0.15	0.30	0.45	0.15	0.30	0.45	0.15	0.30	1.50	Strong medicinal
0.90	0.32	0.58	0.90	0.30	0.60	0.90	0.30	0.60		
Union Pump† (75 minutes pumping)										
0.45	0.20	0.25	0.45	0.20	0.25	0.45	0.18	0.27	1.50	Strong medicinal
0.90	0.40	0.50	0.90	0.40	0.50	0.90	0.38	0.52		

* Allowed to stand 10, 20, and 30 minutes before adding orthotolidin.

† Water stood over night before making tests.

sulted, probably because of chlorination of 6 prior to admixture. The laboratory tests are given in tables 2, 3 and 4.

Before the above samples were taken the wells had been shut down, and the samples were taken fifteen and seventy-five minutes after starting up in order to ascertain whether there was any difference.

Aeration, activated carbon, and ammonia were seriously discussed as to practicability. Meantime pumpage was maintained from 6-B and 6-A alone, yielding a station output of 2.5 m.g.d. Well 6 and Union wells were pumped continuously for months but discharged to waste into a stream running through the grounds with the idea of possibly exhausting the contaminated water. However, laboratory tests with chlorine at intervals showed no improvement. The discharge to the brook produced a heavy filamentous tuft-form jelly growth which proved to be of crenothrix character. Samples of this

TABLE 4

CHLORINE, P.P.M.			TASTE			IRON, P.P.M.
Dose	Residual*	Absorbed	Before chlorination	10 minutes after chlorination	30 minutes after chlorination	
Well 6 (15 minutes pumping)						
0.45	0.05	0.40	Iron	Strong medicinal	Strong medicinal	0.65
0.90	0.30	0.60	Iron	Strong medicinal	Strong medicinal	
1.35	0.65	0.70	Iron	Strong medicinal	Slight medicinal	
1.80	1.20	0.60	Iron	Chlorine	Very slight chlorine	
Well 6 (75 minutes pumping)						
0.45	0.04	0.41	Iron	Strong medicinal	Strong medicinal	0.65
0.90	0.28	0.62	Iron	Strong medicinal	Strong medicinal	
1.35	0.70	0.65	Iron	Less strong medicinal	Less strong medicinal	
1.80	0.85	0.95	Iron	Slight medicinal	Very slight medicinal	
2.25	1.10	1.15	Iron	Very slight chlorine†	Very slight chlorine†	

* Allowed to stand 10 minutes after adding chlorine before adding orthotolidin.

† Slight medicinal after destroying excess chlorine.

growth decaying in jars produced a frightful sewage-like odor. Small amounts treated with chlorine gave a somewhat medicinal flavor, and on the chance that this might be the source of the trouble, the Union wells and well 6 were treated with copper sulphate, then chlorine installed and continuously applied for months while the water was pumped to waste. Well 6 was thus chlorinated and wasted for five months from February to July, 1929. But the medicinal flavor persisted, indicating that crenothrix was probably not the cause, particularly as the visible jelly growth also disappeared following the introduction of chlorination.

SUPERCHLORINATION AND DECHLORINATION

After the Toronto convention and experiencing the wonderfully fine taste of the water supply during a period of application of superchlorination and dechlorination, at the suggestion of Allan M. E. Johnstone, of Wallace and Tiernan, Inc., it was decided by C. J. Keily, Superintendent, of the Jamaica Water Supply Company, to try the process at this station, particularly as additional water was sorely needed on account of peak loads demanded by hot weather.

On July 11, 1929, all the water of the station was pumped to waste to the stream while we experimented with varying dosage of chlorine and tasted. High dose of chlorine (1.75 p.p.m.) at well 6 did not destroy the taste in twenty minutes, but on standing two hours in a bottle taste was not noticeable. Even 3 p.p.m. chlorine was ineffective to prevent taste in the short time of contact available. High dose of chlorine (3.5 p.p.m.) did destroy more completely the taste in the water of the Union wells at this time. Possibly the higher iron content acted as a catalyzer. Varying combinations of the wells with various dosage of chlorine were tried, including high dosage of 6-A and 6-B, so as not to immediately dilute the high chlorine water of well 6 with low chlorine water, and thus get more contact to and through the receiving well. However, with all combinations there was still a slight medicinal flavor at the main pump. Finally, with all wells on, low chlorine dosage of 6-A and 6-B and superchlorination of well 6 and Union wells, the residual chlorine at the main pump discharge was only 0.30 p.p.m. Sulphur dioxide was then applied until only 0.05 p.p.m. residual chlorine was present as a maximum.

At this time two tests were made with chlorine solution to determine the amount of residual sulphur dioxide present, if any. To 100 cc. portions of the station water as discharged from the main pump was added 1 and 2 cc. of a chlorine solution of definite strength making the addition of 0.32 and 0.64 p.p.m. chlorine respectively. Reaction was very slow and it took about thirty minutes to get complete results. The results are shown in table 5.

The results indicate about 0.11 to 0.13 p.p.m. excess sulphur dioxide present in the water, whereas the direct residual chlorine test indicated about 0.03 p.p.m. chlorine in one-half hour color development (increasing to 0.10 p.p.m. in one hour color development). Evidently considerable time must be allowed for reaction of these dilute amounts of chlorine and sulphur dioxide, and the actual condition of the water may be that it contains a slight residual of either chlorine

or sulphur dioxide. However, orthotolidin standards were left at the station and instructions given to maintain a bare residual of chlorine. At 4:00 p.m. the water was turned into the mains and the process was continuously maintained up to March 5, 1930, with no complaints except once when attempt was made to lower the superchlorine dosage. The average output of the station was thereby increased to 3.5 m.g.d. with peak loads up to 4.5 m.g.d. There was a slight medicinal taste in the station water, but none at the nearest house, 450 feet away. For four months previous to discontinuing the process the water discharged from the station had absolutely no medicinal flavor.

The machines installed at wells 6-B and 6-A are Wallace and Tiernan MSA type (glass syphon tubes of older type), at well 6 MSV type (vacuum), at Union wells MSP type (glass syphon tubes of the newer type) and at the main station for sulphur dioxide MSV type

TABLE 5

Determination of residual sulphur dioxide

CHLORINE ADDED	CHLORINE RESIDUAL WITH TIME OF COLOR DEVELOPMENT				CHLORINE ABSORBED
	3 minutes	5 minutes	14 minutes	34 minutes	
	p.p.m.	*p.p.m.*	*p.p.m.*	*p.p.m.*	*p.p.m.*
1 cc. = 0.32 p.p.m.	0.03	0.04	0.10	0.20	0.12
2 cc. = 0.64 p.p.m.	0.25	0.27	0.32	0.50	0.14

(vacuum with chlorine meter). The sulphur dioxide is determined by multiplying the weight of chlorine indicated by 0.9 (ratio of the molecular weights, $Cl_2:SO_2 = 71:64$).

The records of the station have been carefully compiled and the indication of the machines checked by the tanks of chemicals consumed for the five months, July through November. Data since then have been similar. Similarly for the same period the average pumpage has been determined. Variations have occurred at different times of day depending upon water demand, but conditions have been kept as uniform as possible as the easiest way to handle the situation. The dosage has been calculated from the tanks of chemicals as the more reliable figures. Average conditions are then represented by the data in table 6.

Individual tests at the plant at various times indicate that the chlorine absorbed by well 6-B and Union wells is about 0.60 p.p.m.

due largely to ferrous iron, that the absorption by wells 6-A and 6 is about 0.35 to 0.45 p.p.m., although at times absorption at well 6 has apparently been as high as 1.0 p.p.m. The laboratory tests with chlorine in December, 1928, (see tables 3 and 4) indicated absorption varying with dosage and time of contact as shown in table 7.

Attempt was made to estimate the time of contact by changing dosage and noting the time required for the change to appear and also by residual tests for chlorine at various points. In this way it was ascertained that about twelve minutes elapsed between well 6 and the main pump in the station, that five to eight minutes elapsed

TABLE 6

Average pumpage and dosage

	PUMPAGE	DOSAGE		
			Pounds per day	P.p.m.
	m.g.d.			
Well 6-B	1	Cl	1.9	0.23
Well 6-A	1	Cl	3.7	0.44
Well 6	$\frac{3}{4}$	Cl	10.2	1.63
Union wells	$\frac{3}{4}$	Cl	10.1	1.61
Station discharge	$3\frac{1}{2}$	SO_2	16.5	0.56

TABLE 7

Amount of chlorine absorbed p.p.m.

Well 6-B	0.36–0.68
Well 6-A	0.33–0.57
Well 6	0.40–1.15
Union wells	0.25–0.60

between point of application of chlorine to the old well line and the Union pump for first effect and full effect of change of dosage. All the chlorinated water was discharged into one corner of the receiving well and the sulphur dioxide applied at the diagonally opposite corner. Probably not more than ten minutes elapsed in passing through the receiving well. The dimensions of the receiving well are approximately 30 by 20 by 12 feet water depth, holding 54,000 gallons. Pumpage at 3.5 m.g.d. for full displacement equal about twenty-two minutes. As water entered, however, toward the bottom and left near the bottom, short-circuiting was probably occasioned so that

ten minutes is fairly representative. On cutting out the chlorine at well 6, reduction in residual was noted in five minutes, but it took fifteen to twenty minutes before all chlorine disappeared, probably because the chlorine was introduced into the gravel and not directly to the suction of pump, and also chlorine may be held in combination with iron and slowly given up. Similarly it took ten minutes for chlorine to appear when first applied. As the water from wells 6-B and 6-A meet the discharge of well 6 and dilute it, very little effective contact could exist beyond that point, unless 6-A and 6-B were heavily dosed also. One determination of residual chlorine in the receiving well where the chlorinated water entered showed only 0.11 p.p.m. on February 5, 1930. On the day the process was started, July 11,

TABLE 8

Time of contact

	LENGTH OF PIPE	DIAMETER OF PIPE	AMOUNT DELIVERED	RATE	TIME OF TRANSIT
	feet	*inches*	*gallons*	*m.g.d.*	*minutes*
6-B to 6-A	498	16	5199	1	7.3
6-A to 6	440	16	4594	2	3.2
6 to receiving well	339	17*	3997	2¾	2.1
Union to receiving well	383	12*	2250	¾	4.3
SO_2 to house	450	12	2644	3½	1.1

* Average.

1929, with all wells in operation, and before sulphur dioxide was applied, residual chlorine at the main pump was only 0.30 p.p.m. Similarly when 6-B and 6-A with regular dosage and 6 with high dosage were pumped before the addition of sulphur dioxide, residual chlorine at the main pump was only 0.07 p.p.m. It would appear therefore that effective contact with any considerable amount of chlorine was not over five to ten minutes at either well 6 or the Union wells, occurring at well 6 in the well itself and for Union wells in the collecting main, the chlorine being introduced at the furthest end.

The pipe dimensions and volume pumpage have also been taken into account to estimate time of possible contacts and are given in table 8.

Allowing 10 minutes for contact in the receiving well, the time from well 6 to sulphur dioxide application equal twelve minutes, from point of chlorination of Union wells to sulphur dioxide application equal

fourteen minutes. If the full capacity of the receiving well without short circulating is taken into account, and time of contact in well 6, contact could not be over thirty-four to twenty-six minutes and most of this with only slight excess chlorine.

Cost of chemicals has been 92 cents per million gallons with chlorine at 10¼ cents a pound and sulphur dioxide at 8 cents a pound. The average increased water available has been 1 m.g.d. with 2 m.g.d. on peak demands, which has been very important with a water shortage. One great advantage of the process was that it could be and was quickly applied with very little additional equipment required.

Appreciation must be expressed to Superintendent C. J. Keily for his active and interested coöperation in carrying out the details of this treatment and furnishing data for this paper.

DISCUSSION

George R. Spalding:[3] Dr. Hale's sucessful treatment of well waters in Long Island, New York, by superchlorination for the removal of odor producing substances introduced by wastes from a gasoline filling station serve particularly to focus attention upon the increasing variety of contaminating substances that the water works chemist is called upon to eliminate. The resourcefulness of the chemist in handling these problems is often taxed to the limit as is indicated by an experience of the Hackensack Water Company which took place in 1927.

The contaminating substance in this case was an oxidation product of kerosene known to the trade as "aldehol" and brought out as a direct result of the prohibition enactment in an effort to provide a non-poisonous alcohol denaturant which would be proof against removal.

Due to lack of proper provision for disposal of wastes from the factory in which this material was being manufactured, a quantity of the substance found its way into a stream which forms one of the sources of supply of the Hackensack Water Company, producing an odor and taste variously described by consumers, as iodine, carbolic, tar, etc. Superchlorination and subsequent dechlorination with sulphur dioxide were resorted to with but partial success. As the occurrence took place in January, at a time when there was abundant

[3] Assistant Superintendent, Filtration and Sanitation, Hackensack Water Company, New Milford, N. J.

precipitation, the contamination was controlled by drawing off large amounts of water from the impounding reservoir affected. Provision for collection of all plant wastes and their removal from the watershed in tank cars was then instituted.

During the occurrence, and subsequently thereto, considerable research work was carried on in the Hackensack Water Company laboratories in an effort to determine a practicable method for elimination of this substance known as aldehol. In the spring of last year very gratifying results were obtained by the use of activated char applied to the water in conjunction with the regular alum coagulation process. The results of these laboratory experiments were brought out in a paper which I presented at the spring meeting of the American Water Works Association, Eastern Section, at Elmira, New York, in April, 1929. Summarizing these early experiments, it was found less than 0.5 grain per gallon of *"Nuchar,"* pulverized to pass a sieve 300 meshes to the inch, would entirely remove "aldehol" in a concentration of one part in a million, when applied to the water as an adjunct to coagulation with alum.

During the spring of 1930 the Hackensack Water Company has developed this method of utilizing activated char as a deodorant by conducting a plant scale test of twenty-four days duration in which the finely pulverized char was introduced by a dry feed machine into the mixing chamber approximately at the same time and place as the alum. Laboratory experiments had indicated that the amount of char necessary for removal of ordinary odors of vegetable origin common in surface waters would be considerably less than the dosage required for such substances as "aldehol" and phenols.

Nevertheless, surprising results attended this test as it was found that no more than 10 pounds of the char per million gallons of water treated were sufficient to remove distinct fishy and vegetable odors due to Dinobryon and Asterionella, producing a water of superior palatability. No difficulty was experienced in feeding the char with an ordinary Wallace and Tiernan dry feed machine fitted with a water eductor. The finely pulverized char takes up moisture upon storage which must be compensated for, but has no adverse effect upon its efficiency.

The results of various bottle-experiments confirmed by an actual plant-scale test of twenty days duration indicate that this method of applying pulverized activated char furnishes an efficient and readily adaptable method of deodorizing water wherever it is applicable.

Activated char will remove by absorption, certain odor and taste producing substances in water which are difficult or impossible of removal by other means. Because of this, together with the fact that no expensive equipment or installation is necessary for applying the material, we have at our disposal a new method of odor control that should be particularly valuable for emergency purposes.

PROGRESS IN SUPERCHLORINATION TREATMENT FOR TASTE PREVENTION AT TORONTO, ONTARIO[1]

By N. J. Howard[2]

Superchlorination followed by dechlorination treatment of the city water for the prevention of taste, was first successfully demonstrated in Toronto in September, 1926, when for a period of two weeks approximately 70 million Imperial gallons were treated daily. Due to lack of proper equipment and the necessary funds, the practice was discontinued until the early summer of 1927, since when the entire supply varying between 75 and 100 million gallons daily has been successfully treated.

The writer in 1922, at the Philadelphia meeting of the American Water Works Association[3] presented the earliest detailed figures of the amount of phenol in water which was capable of causing taste following chlorination, together with some figures relative to the effect of super doses of chlorine on phenolated water. In 1926, the complete results of experimental work carried out at Toronto, covering a period of several years, was given at Providence, before the New England Water Works Association.[4,5] Reference is especially made to these papers because they cover the subject in considerable detail, and may be of value to those seeking information on this important question. It is not proposed to discuss or review the conditions at Toronto leading up to the introduction of taste prevention treatment, because the subject has been fully covered in the papers previously mentioned, but rather to enlarge upon them and

[1] Presented before the Water Purification Division, the St. Louis Convention, June 4, 1930.

[2] Director, Filtration Plant Laboratories, Toronto, Ontario, Can.

[3] N. J. Howard. Modern Practice in the Removal of Taste and Odor. Jour. Amer. W. W. Assoc., 9: 766 (1922).

[4] N. J. Howard and R. E. Thompson. Chlorine Studies and Some Observations on Taste-Producing Substances in Water, and the Factors Involved in Treatment by the Super- and Dechlorination Method. Jour. New Engl. W. W. Assoc., 40: 3, 276–296.

[5] N. J. Howard and R. E. Thompson. Discussion of Above. Jour. New Engl. W. W. Assoc., 41: 1, 59–62.

give results of observations covering the past two years, during which period some interesting equipment has been installed.

EQUIPMENT AND EARLY DIFFICULTIES

The changes in equipment during the period covered by superchlorination have been numerous and extensive. At the outset, chiefly on account of the radical nature of the treatment, and the fact

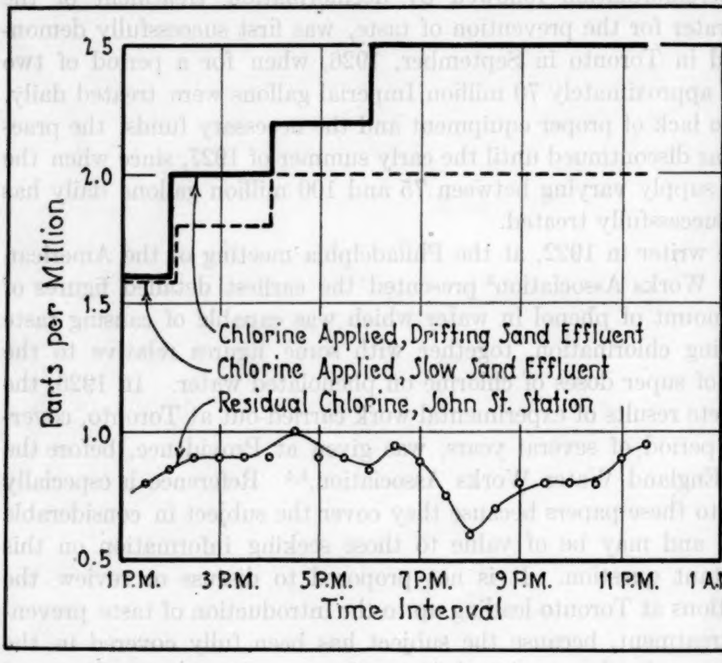

FIG. 1. CHLORINE APPLIED AND VARIATIONS IN CHLORINE ABSORPTION, APRIL 6, 1930

that by some it was regarded as a big experiment fraught with certain dangers, difficulty was experienced in securing the necessary support and appropriation for a practical demonstration on the city supply. We were able to apply the treatment on a large scale in 1926, through the courtesy of the Wallace and Tiernan Company, in loaning six old type machines, which were overhauled at the city's expense and placed in commission. In 1927, the city officials were satisfied as to the success of the treatment and purchased several new machines,

and at the present time 10 chlorine machines and 8 sulfonators of the vacuum pedestal type are in commission, having a combined capacity of 5,400 pounds daily.

The earliest difficulty experienced was in maintaining an adequate operating sulphur dioxide cylinder pressure. Under heavy consumption conditions, amounting to close upon 1,400 pounds daily, the pressure quite frequently dropped to less than 10 pounds, which was insufficient to continuously operate machines of 300 pounds capacity. This was partly overcome by maintaining a room temperature of 100°F., and the placing of steam coils at the base of the cylinders. While this greatly improved operating conditions the explosive hazard always existed, and on one occasion the blowing of a fuse plug in the middle of the night caused several buildings to become full of gas fumes and temporarily rendered operation difficult. The outcome of this was the installation of evaporators, loss of weight recording scales and the use of one-ton containers shipped 15 to the car. This equipment is identically the same as that used by the chlorine manufacturers.

Using this equipment, sulphur dioxide is drawn off as a liquid and continuously discharged into the bottom of a 150-pound steel cylinder immersed in a water bath, the temperature of which is thermostatically controlled. By maintaining a water temperature of 190°F. an operating pressure from 45 to 50 pounds is uniformly maintained, until the container is nearly emptied. A rapidly decreasing pressure is the indication of this condition and the new container is cut in immediately a zero pressure is recorded. Experience has shown that the containers are practically emptied each time. The contractors however allow a return credit of 15 pounds on each container. It is essential that the valves between the evaporator and one-ton container should always be left open in order to equalize the pressure, to prevent the small cylinder in the evaporator becoming overloaded and preclude the possibility of discharging liquid sulphur dioxide into the manifolds. On one occasion, under low consumption conditions, the operator temporarily closed the valve between the evaporator and one-ton container. This resulted in an excessive pressure being developed in the evaporator cylinder and the discharge of liquid into the manifold, flooding all the connections to the machines and causing the immediate freezing up under the bell jar of 7 machines. Ice formed to a depth of nearly two inches on the valves, necessitating the use of a blow torch for a period of two hours to correct the condition.

The hourly loss of weight is automatically recorded on the scale charts, which in practice have been found to be remarkably accurate, the average error under maximum conditions of operation being less than half of one percent. To guard against breakdown, an entirely separate installation is provided which can be cut in immediately should it be required. The manifolds through which the gas flows to the sulfonators are made of heavy brass piping. The one-ton containers are shipped on multiple unit tank cars under frames holding 15 cylinders. Cars are leased to the city free of cost so long as they remain on the waterworks siding thus avoiding demurrage payment. The cylinders are unloaded by a crane and transported to the dechlorinating room nearby. With proper care and equipment the containers are easily handled.

OPERATING DATA

The new installation, which is the largest of its kind in the world, has been found to work satisfactorily, is simple to operate and has been the means of overcoming our operating difficulties. The use of one-ton containers has resulted in a marked reduction in the price of sulphur dioxide. The following figures show the contract prices per ton of sulphur dioxide since the treatment was inaugurated:

YEAR	PRICE, IN DOLLARS PER TON	
	150-pound cylinders	1-ton cylinders
1926	260.00	–
1927	225.00	–
1928	162.33	–
1929	148.00	128.00
1930	–	117.86

It may be of interest to discuss briefly the conditions dealing with quality of water and operating costs. Unlike the conditions in many other cities the free ammonia content of the raw water is very low, the average figures for 1929 being 0.013 and 0.009 p.p.m. in the two intakes respectively. The pollution of the water which gives rise to taste in Toronto is always accompanied by excessively high free ammonia conditions. During the past year the figures recorded during 24-hour periods quite often ranged between 0.001 and 0.300 p.p.m. These rapid variations render the treatment of the water extremely difficult, if effective and economical operation is to be main-

tained. With low free ammonia content the chlorine absorption is very small and large quantities of sulphur dioxide may be necessary for dechlorination; with high free ammonia the chlorine absorption is rapid. On figure 1 it will be seen that the chlorine residual at one

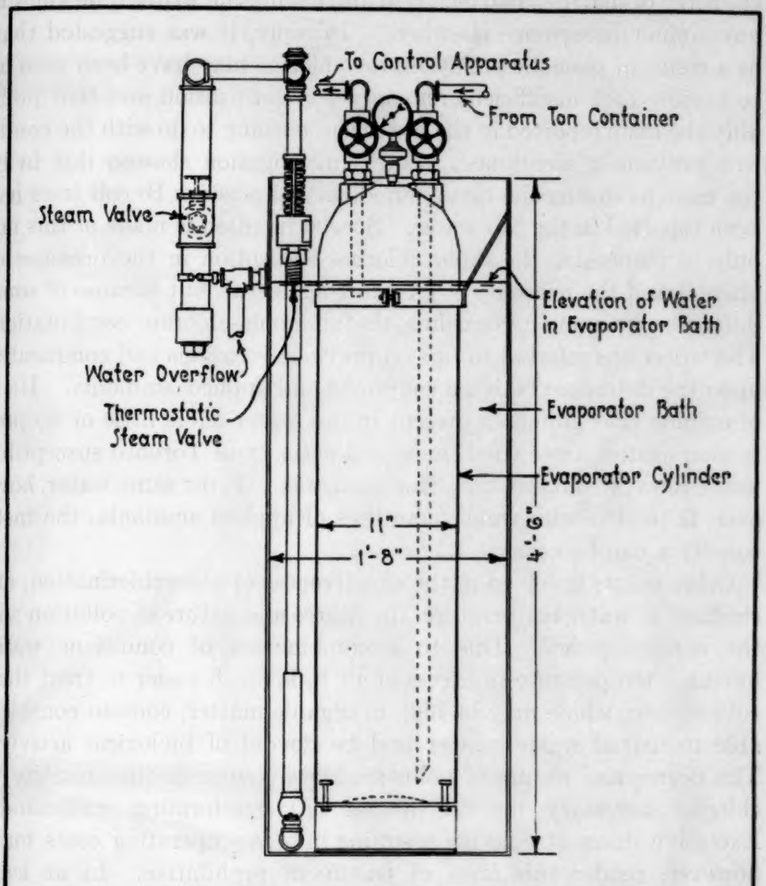

FIG. 2. SECTION OF EVAPORATORS

period amounted to only 0.60 out of an average applied dose of 2.30 p.p.m. When it is considered that this quantity of chlorine was used up in the filtered effluent, and that under normal water conditions when the free ammonia is low, often less than 0.15 is used up out of 0.325 p.p.m. applied under post-chlorination treatment the additional protection afforded by superchlorination is apparent.

If abnormally high free ammonia occurred with a low chlorine dose the effect might be serious. A practical example of this may be given. A few years ago a letter of enquiry was received, stating that following a pronounced chemical taste in a water supply, an epidemic of diarrhea had occurred and asking the writer if he knew of any similar occurrence elsewhere. In reply, it was suggested that, as a result of phenolic pollution, the chlorine may have been used up so rapidly that insufficient remained for sterilization and that probably the taste reported in the water had nothing to do with the condition previously mentioned. Later investigation showed this to be the case, as during the taste period several positive B. coli tests had been reported in the tap water. Special mention is made of this not only to emphasize the rapid chlorine absorption in the presence of phenols and the necessity of guarding against it, but because of some difference in opinion regarding the ammonia-chlorine combination. The writer has referred to this on previous occasions and commented upon the difference between contained and applied ammonia. He is of opinion that ammonia present in raw water offers little or no protection against taste conditions, and actually in Toronto susceptible water always contains high free ammonia. If the same water, however, is treated with small quantities of applied ammonia, the taste condition can be corrected.

Other points involved in the effectiveness of superchlorination, are confined to water temperature, the degree and nature of pollution and the contact period. Due to a combination of conditions water having a temperature in excess of 46°F. is much easier to treat than colder water which may be high in organic matter, contain considerable industrial waste matter and be devoid of biological activity. The degree and nature of pollution largely controls the quantity of chlorine necessary for destruction of taste-forming compounds. Excessive doses of chlorine resulting in heavy operating costs may, however, render this form of treatment prohibitive. In at least three known instances outside of Toronto, the treatment has proven ineffective in preventing taste in spite of the application of large amounts of chlorine. It is possible that insufficient amounts of chlorine were applied, and that had it been practical to carry the treatment further, taste could have been prevented. If the chemical pollution of a raw water is so intensive and of a nature that it imparts a chemical taste to the water prior to chlorination, as has been reported, superchlorination treatment may prove of limited value.

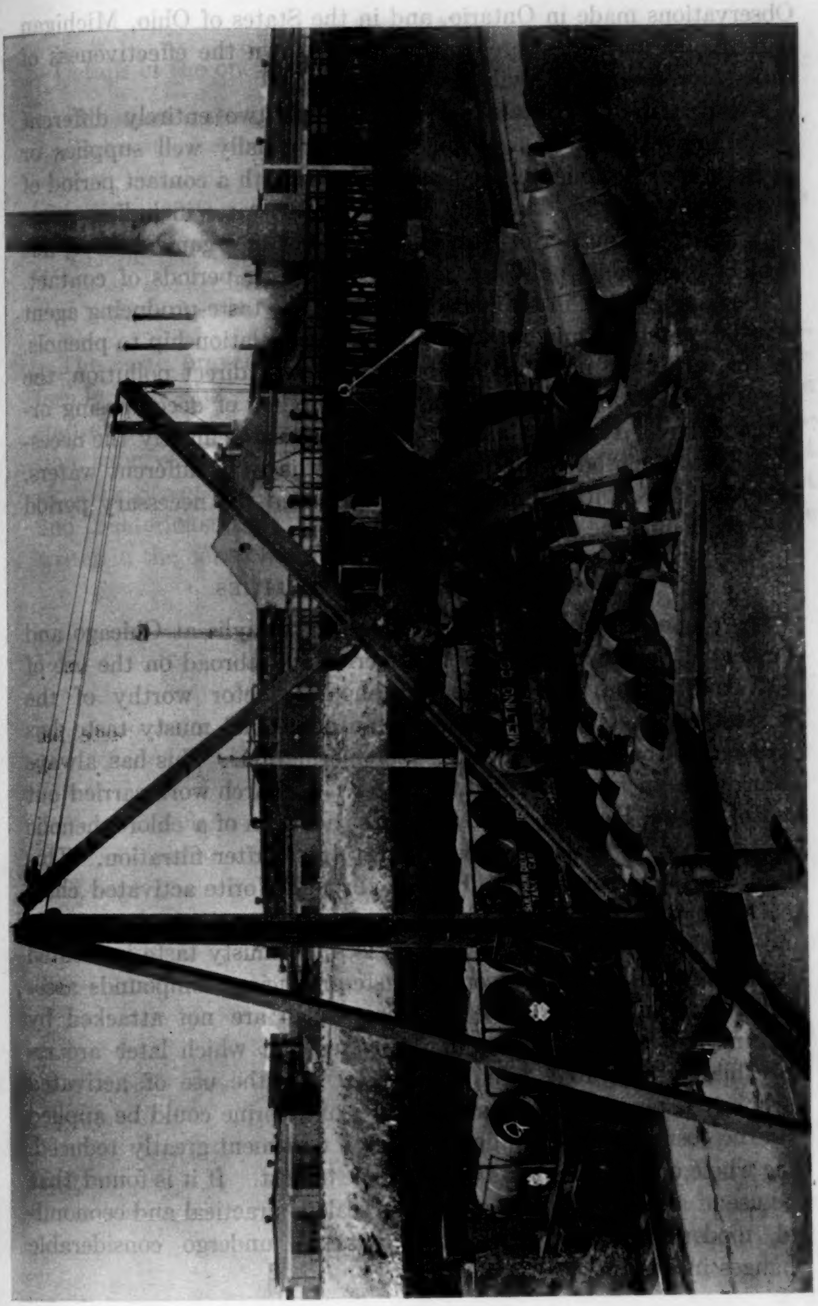

FIG. 3. UNLOADING ONE TON CYLINDERS OF SULPHUR DIOXIDE

Observations made in Ontario, and in the States of Ohio, Michigan and Illinois and elsewhere, have clearly shown the effectiveness of superchlorination in heavily polluted water.

Relative to the contact period there are two entirely different conditions existing. One type of water, usually well supplies or water of high organic purity, can be treated with a contact period of a few minutes only, while the other type of water including water high in organic matter or water normally low in organic matter, but subject to periodic pollution, may require long periods of contact. It is suggested that in the former grouping the taste-producing agent may be present in mineral form and have no relationship to phenols. In the latter the phenols may be present as a direct pollution, the result of bacterial decomposition or the product of decomposing organic matter. It is very important to ascertain definitely the necessary contact period which may vary enormously in different waters. Likewise, the relationship of temperature and the necessary period of contact must be determined.

ACTIVATED CARBON POSSIBILITIES

The pioneer work carried out by John R. Baylis at Chicago and duplicated by other observers in America and abroad on the use of activated carbon, has introduced another factor worthy of the greatest consideration. In Toronto an occasional musty taste has occurred in the water following superchlorination. This has always occurred in an intensely polluted water. Research work carried out at Rotterdam, Holland, showed that the addition of a chlorophenolic solution to river water produced a musty taste after filtration. This taste was later removed by filtration through Norite activated charcoal. To the writer it would seem to be an important observation, and to offer evidence, that in some cases the musty taste in treated water may be caused by certain taste-producing compounds associated with industrial waste pollution which are not attacked by chlorine and remain present in the water, but which later are removable by activated carbon filtration. By the use of activated carbon it is probable that smaller doses of chlorine could be applied and the cost of super- and dechlorination treatment greatly reduced. The whole question narrows down to one of cost. If it is found that the use of activated carbon on a large scale is practical and economical, modern filtration plants may have to undergo considerable changes in design.

COST DATA

Details of the operating costs at Toronto for 1929 were as follows:

Chlorination of water	$32,236.47
Super- and dechlorination treatment	$20,027.56
	$52,264.03

Cost per million gallons based upon an average of 75.99 million imperial gallons daily

Chlorination of water (continuous)	$1.09
Super- and dechlorination treatment (applied during periods of probable taste)	$0.72

The taste prevention treatment of the city water has been uniformly successful and has been operated with the coöperation of the staff at a minimum cost. Mr. L. F. Allan, Superintendent of Filtration, supervised the installation of the new dechlorinating equipment at John Street Pumping Station. Mr. R. E. Thompson, Chemist and Bacteriologist, Filtration Laboratories, is associated with the writer in the control of the super- and dechlorination treatment.

THE ELIMINATION OF TASTE AND ODOR IN THE WATER SUPPLY OF LANCASTER, PENNSYLVANIA[1]

By Edward D. Ruth[2]

The water consumers of the City of Lancaster had a just cause for complaint. The taste and odor of chlorine was present in the water almost continually. The first person to draw water from a tap in the morning was always greeted with the medicated smell and taste of chlorine. Spring freshets brought horrible taste and odors. Hot dry summers caused odors that varied; grassy, fishy, mouldy, and a taste that resembled that of stale distilled water.

FILTER PLANT DATA

The filter plant is a freak one designed in 1907 by P. A. Maignen. There are 15 sand beds, 140 feet long, 16 feet wide, and 6 feet deep. There is a preliminary filter or so called scrubber, ahead of each of the sand beds. These preliminary filters are 35 feet long, 16 feet wide, and 6 feet deep. They receive the raw, settled, and coagulated water from the bottom. The water percolates upward through 42 inches of furnace slag and coke, the coke being from nut to egg size, and the furnace slag rice coal size. The effluent from the preliminary filters flows over a weir wall to the adjoining sand bed, which is made up of 18 inches of crushed stone, graded from 3-inch size at the bottom, to ½-inch stone at the top. There is 30 inches of very coarse sand. Originally this sand passed a No. 14 sieve, and was retained on a No. 80 sieve, but the fine grains have long since been washed out.

The plant was designed to filter 8 m.g.d., but we had to operate it up to 12 m.g.d. Several years ago we metered all of the services, and last year a pitometer survey revealed a number of leaks, so that we have reduced the pumpage to a maximum of 9 m.g.d., but as there is just about one half acre of sand beds, we are operating them at the high rate of 18 m.g.d. per acre, and prior to the reduction in pumpage

[1] Presented before the Water Purification Division, the St. Louis Convention, June 5, 1930.

[2] Consulting Engineer, Lancaster, Pa.

we were operating them up to the rate of 24 m.g.d. per acre. Of course, we had to rely on chlorine for more than 20 percent of the bacterial reduction, and, in consequence, the chlorine dose had to be high to keep within the U. S. Treasury Department standard. As a matter of fact, we were not always able to keep within that standard, as to the agar count and B. Coli content, and there was always present in the finished water at least the odor of chlorine.

The chlorine dose varied from 0.45 up to 3 p.p.m. The agar counts from city taps frequently ran up to 125 per c.c., pink colonies up to 10 per c.c., aerogenes and B. Coli up to 0.2 per c.c.

EXPERIMENTS WITH AMMONIA

During the month of April, 1928 we started to experiment with carbonate of ammonia, applying it to the raw water by means of a Wallace and Tiernan dry feed machine of the rotary table type, starting off with what we thought was 0.18 p.p.m. This produced very definite results, but we soon found that carbonate of ammonia is a very unstable chemical.

We then made an effort to have a large manufacturer of chlorinators make up an all iron device to feed anhydrous ammonia gas, along the same lines as the conventional chlorinator, but up to February, 1929 we had not succeeded. We then had a talk over the telephone with the manager of another concern manufacturing chlorinators, and we finally obtained a regulating and feeding device about the second week in June, 1929.

We began experimenting with the new device immediately, and the results were simply marvelous. After some weeks of experimenting we found that feeding equal quantities of ammonia gas, and chlorine by weight, gave the best results, and we also found that we could reduce the chlorine dose to 0.18 p.p.m. feeding the same dose of anhydrous ammonia, and all taste of chlorine or any other taste or odor in the water was entirely eliminated. The agar counts in the city taps have never been over 30 per c.c. and frequently down to zero, no aerogenes, no pink colonies and no B. Coli, and a chlorine residual of not less than 0.25 p.p.m. in the city taps.

We take our water supply from the Conestoga river. The area of the water shed above the pumping station is 310 square miles, fully 90 percent of which is cultivated land. The population per square mile is 123. The turbidities range from 3 to 16000 p.p.m. The pumping station is located on one bank of the river, and the filter

plant on the opposite bank. The raw water is pumped into an enclosed concrete tank, and the anhydrous ammonia gas is fed dry, directly into the raw water in this tank at the point where the water enters it, and just about four feet ahead of the sulphate of alumina feed. From this tank the water flows to a sedimentation basin, 80 feet by 80 feet by 13 feet 6 inches deep, in over a baffled weir and out over a baffled weir, and from the effluent weir through a pipe line to the influent conduit of the filter plant. The effluent water from the filters is collected in a conduit from which it is conducted through a pipe line to a clear water reservoir. The chlorine is fed into this pipe line by means of solution feed machines. The period of time intervening between the ammonia contact, and the chlorine contact, is about one hour and thirty minutes.

We now get lower agar counts from the water as it enters the clear water reservoir, and very much lower counts from the city taps located from one to four miles distant from the filter plant. The germicidal action of the chlorine is slower at the filter plant, but greatly increased at the distant points, that is, we get lower counts from the city taps. We experimented for more than a year with prechlorination, but with no beneficial results. We had some relief from superchlorination during periods of high turbidity, caused by spring freshets, but the relief was uncertain, and the proper dosage was difficult to determine.

We also used permanganate of potash, not in the elimination of taste and odors, but in oxidizing dead vegetable growths in the raw water. During the season beginning April 15 to December 1, of each year, our stream abounds with vegetable organisms, and we feed copper sulphate in a dry feed machine, mixing the ground copper sulphate, with ground sulphate of alumina, in the proportion of one part of copper sulphate to three parts of sulphate of alumina. Up to the summer of 1929 the maximum dose was 0.78 p.p.m., but during September, October and November of this year, we had to go up to 1 p.p.m. and then the dead vegetable growths clogged the filters, and raised the bacterial counts of the water in the filter beds up into the thousands. We then fed permanganate of potash in a dry feed machine up to 5 p.p.m., until we had the filters cleared, and then cut the dose to 0.63 p.p.m.

We had a long dry spell during the late summer and fall of 1929, no rain for more than nine weeks. At such times our water showed normally about 5 p.p.m. in turbidity, but during this nine weeks

period, the turbidity readings were not less than 80 p.p.m. These high readings were due to vegetable and amorphous matter in the water.

On September 4, 1929 our chemist found:

Volvox	80,000 per cc.
Tabellaria	50 " "
Amorphous matter	535,000 " "

While some of the above are taste producers, we had no taste even before we started to feed the permanganate of potash.

A characteristic summary of our water for the year, 1929, is shown in table 1.

TABLE 1

		Turbidity	Alkalinity	pH	CO_2	Agar counts 37°C.
Raw water	Maximum	1600	159	8.4	8.2	42,500
	Minimum	2.5	34	7.2	0.0	60
	Average	64.4	112.4	7.74	3.26	1,751
Settled water	Maximum	200	160	8.4	50	5,750
	Minimum	2.5	10	4.5	0	39
	Average	18	105.9	7.62	5.4	544
Filtered water	Maximum	7	142	7.9	42	95
	Minimum	0.2	8	5.2	2.6	3
	Average	1.59	101	7.4	8.1	28

	Residual chlorine	Total hardness	Total solids
Maximum	0.37	148	281
Minimum	0.025	74.7	142
Average	0.24	123.3	193

	Organic matter	Nitrogen, as free saline ammonia	Nitrogen, as albuminoid ammonia
Maximum	143	0.010	0.056
Minimum	40	0	0
Average	95.7		

Nitrogen, as nitrite	Nitrogen, as nitrate	Chloride
Absent	2.1	5.5

PREAMMONIATION OF THE FILTERED WATER SUPPLY OF CLEVELAND, OHIO[1]

By J. W. Ellms[2]

Tastes of an offensive character in the water supply of Cleveland, Ohio, caused by the presence of chlor-phenolic compounds, have been comparatively rare and of but a few days duration during the past six or seven years. The by-product coke oven plants, from which the major part of the contaminating wastes came, have been recirculating them through a system of tanks for several years, and using the concentrated liquors for quenching coke. However, it is probable that a small quantity of these liquors escapes at times from these plants to Lake Erie through the Cuyahoga River on which the plants are located. Under winter conditions with ice floes blocking the mouth of the river, the ice becomes contaminated, and when moved by the wind, may be carried close to the City's intakes and pollutes the inflowing water. From November until April of the following year these conditions exist, and it is during this period that offensive tastes are likely to occur in the chlorinated filtered water supply of the City.

A special committee, consisting of engineers, chemists and sanitarians, was appointed by the City administration to study this problem and to experiment on a sufficiently large scale in order to find a practical method for its solution. Their attention was first directed to a study of activated carbon for this purpose. After more than two years' work with various types of activated carbon, a report was rendered which condemned their employment for eliminating chlor-phenolic tastes on the score of inadequacy, impracticability and high cost for conditions in Cleveland.

The committee, however, continued its studies, and as a result of experiments with preammoniation of filtered water made a second report recommending the adoption of this process in conjunction

[1] Presented before the Water Purification Division, the St. Louis Convention, June 5, 1930.

[2] Engineer of Water Purification and Sewage Disposal, Department Public Utilities, Cleveland, O.

with chlorination. The process has been adopted and placed in operation at the City's two filtration plants.

AMMONIA AND TASTE PREVENTION

The use of ammonia for the prevention of objectionable tastes in drinking water which is disinfected with chlorine depends on the presumable formation of chloro-amines. The chemistry of the reactions involved when ammonia is applied to a natural water prior to chlorination is more or less obscure. It seems probable, however, that the formation of monochloro-amine and dichloro-amine are dependent upon the hydrogen-ion concentration of the water being treated. Probably in naturally alkaline waters, a mixture of these two amines results. The combination of chlorine or hypochlorous ions with phenolic compounds, when the latter are present, to form chlor-phenolic bodies producing foul tastes, is apparently prevented by the presence of the ammonia.

The theoretical ratio of NH_3 to Cl to form monochloro-amine is 1 to 4.2; and for the dichloro-amine it is 1 to 8.3. Under acid conditions a theoretical ratio of 1 to 3.12 produces NCl_3; and under alkaline conditions a theoretical ratio of 1 to 1.55 forms nitrogen gas. It is, therefore, probable that too great an excess of ammonia is liable to prevent the formation of chloro-amines, while an insufficient quantity may result in an excess of chlorine with the consequent formation of chlor-phenolic taste producing compounds, should phenols be present. Within the range of pH values for most water supplies, there is probably formed a mixture of the monochloro- and dichloro-amines.

The disinfecting property of the chloro-amines is well established, and it is, therefore, desirable to provide if possible the optimum conditions for their production when depending upon them for bactericidal action. They have a somewhat slower action than does chlorine used alone, but they have a continuing inhibitory effect upon bacterial growths which is of great value for maintaining a water supply in good condition during its passage through pipe lines and reservoirs to the consumers. These facts have been confirmed in our experimental work.

EXPERIMENTAL WORK AT CLEVELAND

The experimental work in Cleveland was primarily undertaken in order to find (1) an effective preventive of objectionable tastes produced by the occasional presence of small quantities of phenolic com-

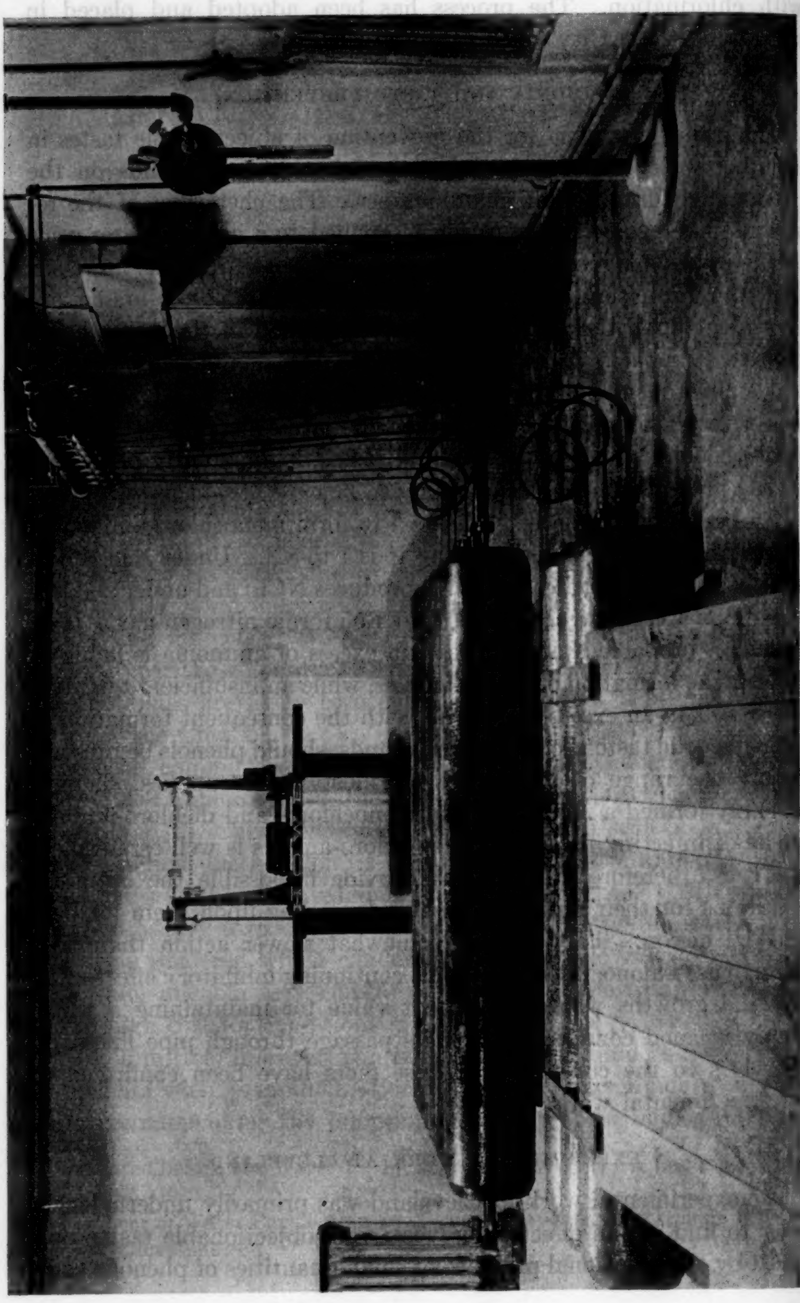

Fig. 1. Ammonia Gas Control Unit, Scales and Manifold at Baldwin Filtration Plant, Cleveland, Ohio

pounds, and (2) to prove the bactericidal properties of the process. For these purposes both laboratory and small plant scale experiments were made, and as a result a large amount of data was collected. It will only be possible in this paper to indicate briefly the important facts established in connection with the treatment of filtered Lake Erie water.

These points may be concisely stated as follows:

1. The application of anhydrous ammonia gas to a filtered water prior to its chlorination prevents objectionable tastes from chlor-phenolic compounds even when phenol is present in a concentration of one part per million.

2. Boiling the water thus treated does not develop the objectionable taste of chlor-phenolic compounds.

3. Chlorinous odors and tastes, which are not uncommon when chlorine is used alone, are also prevented.

4. The compounds formed by treating the water with ammonia before applying the chlorine are relatively more stable than those produced by adding chlorine only, as shown by "residual chlorine" tests, and by a prolonged inhibitory effect upon bacterial growths.

5. The process requires a small amount of inexpensive equipment, which may be used at existing water plants without modification of the latter, and is of low cost for operation and maintenance.

METHOD OF APPLYING AMMONIA

Equipment for applying anhydrous ammonia gas to the filtered water before it is chlorinated was first installed in one of the City's filter plants in the fall of 1929. Operation of this equipment was started on November 1st of last year and has been continuous up to the present time. No ammonia gas control units for feeding the gas to the water being available at that time, manual control through an orifice by means of an ammonia needle valve was employed. A mercury manometer was used to measure the drop in pressure across the orifice, in addition to ammonia pressure gages placed before and after the orifice.

A large platform scale for determining by weight the amount of ammonia gas being used, was placed in a room provided with steam heat. On the scale platform are laid five anhydrous ammonia gas cylinders, each of which contains 150 pounds of the gas. Flexible steel tubing is used to connect each cylinder with a valved manifold or header, on one end of which was placed an ammonia pressure

gage. From the opposite end of the header a $\frac{3}{8}$-in. iron pipe conveys the gas to the section containing the orifice plate, manometer and control needle valve.

At this plant the filtered water is conducted from the plant by two 54-in. diameter cast iron pipe lines into a concrete twin conduit. Feeding the gas directly into these two pipe lines was not at first thought to be practicable, and, in consequence, it was decided to attempt to dissolve the gas in water and to discharge the ammonia water formed into the filtered water mains. After the gas passed the needle valve, therefore, it was conducted into an upright steel cylinder or absorption tank. Filtered water sprayed in at the top of the cylinder dissolved the gas, and the ammonia water formed was drawn off continuously through a pipe at the bottom of the tank and conveyed by two branch lines of practically equal length to the filtered water mains. Within two months after starting this apparatus, the $1\frac{1}{2}$-inch pipe lines which had been conveying the strong ammonia water to the filtered water mains were found to be clogged by an incrustation of calcium and magnesium carbonates. In consequence, the pipes were partially cleaned out, the water spray in the absorption chamber discontinued and the ammonia gas fed directly to the filtered water in the two mains.

The ammoniated water flows a distance of about 900 feet before the chlorine is applied in a gate house opposite the entrance to the two basins of the filtered water reservoir. This reservoir has a capacity of approximately 20 million gallons, and represents on an average about 25 percent of the daily output of the filter plant. From this reservoir the water flows to the pumping station, where it is pumped directly into the distribution system. The foregoing facts are mentioned to show the mixing and detention periods which exist under average conditions at this plant after the application of the ammonia and chlorine.

A mercury ammonia gas control valve unit has been developed for the equipment at this plant, but has not as yet been installed. In spite of the usual difficulties involved in adapting a new process to an existing plant with untried equipment, the application of the gas has been unusually uniform and the results obtained satisfactory.

At the other City filter plant, a Pardee ammonia gas control unit was installed, together with the necessary platform scale, manifold, piping, cut-off and control valves. This equipment has been in continuous use since January 4, 1930, and has proved to be accurate

and easily operated. At this plant conditions were such that the ammonia gas had to be applied at four points, and only a short distance upstream from the point where the chlorine was added. The filtered water is collected from four effluent galleries or reservoirs under each quarter of the filter plant. From these four reservoirs it is conveyed by four 48-inch diameter pipe lines to a concrete conduit divided into two parts by a central partition. The ammonia gas is brought from the control unit on the floor above the conduit to a central point, from which four approximately equal lengths of ½-inch iron pipe permit the gas to be discharged into the four 48-inch mains.

The chlorine from the chlorine machines is discharged through a grid into the ammoniated filtered water at the end of the collecting conduit. The treated water then passes into a small gate chamber and from thence through four large gates to two basins of a large filtered water reservoir, holding 135 million gallons. This reservoir holds about one and one-half times the present output of the plant.

DOSAGES

The ratios of ammonia to chlorine applied at the two filter plants have been purposely varied from time to time. Two pounds of anhydrous ammonia gas to three or three and one-half pounds of chlorine per million gallons have been used at one plant, while at the other plant the quantities have varied from one pound of ammonia to two pounds of chlorine or one pound of ammonia to three or three and one-half pounds of chlorine per million gallons of filtered water. At both plants up to the present time of writing, there have been used 27,132 pounds of anhydrous ammonia gas. This represents at one plant 1.8 pounds of ammonia gas for each million gallons of filtered water, and at the other plant 0.96 pound of ammonia per million gallons of water. At both plants about 235 pounds of ammonia gas are applied daily to the filtered water.

RESULTS OBTAINED

The results obtained from the use of ammonia in these two large filter plants have confirmed our experimental work. No tastes from chlor-phenolic compounds have been noted in the public water supply during the period the ammonia has been used. It is, of course, possible that no phenolic compounds contaminated the water supply during this period; but if they did the addition of the ammonia has

effectively prevented them from uniting with the chlorine to produce foul tastes.

During the colder portions of the year, when the temperature of the water is the lowest, the residual chlorine is always the highest when using chlorine only for disinfection. Hence chlorinous tastes are more likely to be noted than when the water is warmer and the reaction between the chlorine and the water and its constituents more rapid. There has been an entire absence of these chlorinous tastes since using ammonia, although the apparent quantities of residual chlorine have been always higher as shown by the ortho-tolidine tests. The explanation for this fact is not apparent, but there is no doubt that the water has had a more pleasing taste since using ammonia, as evidenced by statements of consumers.

The bactericidal efficiency of this process of disinfection has been carefully studied. Examinations of samples of water from widely separated points in the distribution system for their bacterial content have shown with few exceptions a water of as high a quality, if not higher, than when chlorine alone was used. Eight series of samples, which have been collected during the past six months, covered all of the various pressure services of the metropolitan district supplied with water from the Cleveland plants.

During the last three weeks in December, 1929, 147 samples of water in four series were taken on both the east and west sides of the district. The eastern portion of this area was supplied with water from the filter plant in which chlorine only was being used, and the western portion by the filter plant in which both ammonia and chlorine were being used. This afforded an opportunity of comparing the effect of the two different methods of disinfection at the same time.

The average bacterial count both at 20 degrees C. and 37 degrees C. was 2 per c.c. for samples of water which had been chlorinated only, and 0 and 0.5 per c.c., respectively, for samples of water which had been treated with both ammonia and chlorine. No B. coli were found in any of the samples from either plant. The average residual chlorine for the chlorinated water was 0.013 p.p.m., and for the ammoniated and chlorinated water 0.16 p.p.m.

Four more series of samples (167 samples in all) were taken on both sides of the metropolitan district after the second filter plant had begun to apply ammonia with the chlorine. All samples gave an average bacterial count of one or less per c.c. when incubated at either 20 degrees or 37 degrees C.; and no B. coli were found in any sample.

The average residual chlorine was 0.2 p.p.m. The temperature of the water ranged between 5 and 8 degrees Centigrade.

These results are ample evidence of the efficiency of the process when treating approximately 175 millions of gallons of water daily. They confirm our original experimental work and fully justify its adoption for Cleveland conditions.

ADVANTAGES OF AMMONIA TREATMENT

The advantages of the process may be briefly summarized as follows:

1. No chlor-phenolic tastes have been noted since beginning the application of the ammonia prior to chlorination.
2. Chlorinous tastes from residual chlorine have been eliminated.
3. The taste of the water is more acceptable than ever before, and no complaints from consumers have been received.
4. The bacterial efficiency of the process is as high, if not higher, than when chlorine only is used.
5. The prolonged inhibitory effect on bacterial growths is of great value in maintaining a water in its highest state of purity throughout an extensive distribution system.
6. The cost of the equipment for applying ammonia is merely nominal, and may be readily adapted to any existing water plant. The cost of operation for the ammonia is low, and will not exceed $0.30 per million gallons of water treated, if the ammonia is purchased at $0.15 per pound.

REFERENCES

(1) R. M. Chapin, Jour. Amer. Chem. Soc. 51: 2112 (1929).
(2) Jack J. Hinman, Jr., and Kenneth C. Beeson, Jour. Amer. Water Works Assoc., Vol. 21, No. 12, (1929).
(3) M. M. Braidech, Report of Ohio Conference on Water Purification (1929).

DISCUSSION

HOWARD J. PARDEE:[1] The ammonia-chlorine treatment has been given considerable attention in the last few years as a preventer of chloro-phenol tastes and has come to be looked upon as rather specifically limited to that field. Mr. Ruth appears to be the first to apply the process successfully for the elimination tastes due to organic growths. Since his work the process has been applied for the same purpose at Greenville, Pa. Here, as at Lancaster, a marked taste and odor due to organic growths has been prevented in both hot and cold water, chlorine efficiency has been raised, and after-growths have disappeared. This is reported on in a current issue of Water Works Engineering.

We cannot hope that ammonia will eliminate every taste and odor that finds its way into our different water supplies. There are certain to be disappointments. Our work in the immediate future is to determine just what the process will do and just what it will not do. Mamaroneck, N. Y., is experimenting with it in connection with super-chlorination. The results so far point to success. We trust they will publish their results when the work is completed.

Perhaps the point on which there is at present most confusion is the rate of sterilization. Chlorine sterilization has the remarkable characteristic of almost instantaneous action. The addition of ammonia is, in some cases, reported to slow down this action, although the ultimate sterilization is superior. Under just what conditions does this slow down occur and what does it amount to actually and practically? The work available gives little definite information. Much of it has used chlorine dosages that are just enough and no more. The slightest interference with this razor edge balance could be expected to give irregular results. What would be the results if there were a reasonable increase in the residual chlorine which the ammonia would allow.

The reported difference in sterilization over short periods has, except for a few instances, not been over a fraction of a percent of

[1] Sanitary Engineer, New York, N. Y.

the total sterilization. If this is found to be the rule, is a water sterilized 99.6 practically more unsafe than one sterilized to 99.8 percent.

The process should help materially the gravity where decreased night flows result in tastes from overdosed water when chlorine is used alone. In addition there is work to be done in the swimming pool field and for algae control. There is plenty for every one interested before this process is fitted into its proper niche in the water works field.

Louis B. Harrison:[2] In Bay City chloro-phenol and other tastes appear intermittently, depending on the direction of the wind. A southeaster or northeaster blows over river water to the intake.

They make their appearance mostly in the fall and spring of the year. Experiments have proven that when the temperature of the raw water rises to 47°F. the phenols present in the water undergo auto oxidation, provided they are present in small quantities. In the Saginaw river a condition exists where chloro-phenols are present in the raw water in addition to traces of phenols.

Chloro-phenols are not the only annoying and disagreeable tastes in water. Swampy and musty tastes are as objectionable. While ammonia-chlorine treatment, if properly applied, may prevent the formation of chloro-phenol tastes it has no mitigating effects on other objectionable tastes, and there still remains a problem of taste removal.

After experimenting with activated carbon I am inclined to state that in our case it not only removes phenols, chloro-phenols and allied taste forming compounds, but also removes the musty and swampy tastes.

Bay City has been using ammonia-chlorine treatment for the last two years and while it does not remove the tastes, it does things Mr. Ellms states in his paper.

1. It prevents the formation of objectionable chlorinous tastes.
2. It exerts a prolonged inhibitory effect upon bacterial growth.
3. The water in general tastes better.
4. A smaller dose of chlorine can be used with good results. We keep in Bay City, since this treatment has been resorted to a residual chlorine between 0.03 to 0.09 p.p.m., depending on

[2] Superintendent of Filtration and Pumping, Bay City, Mich.

the time of the year, whereas, in former years we kept a residual chlorine of 0.2 plus p.p.m.

The dosage varies between 1 part of NH_3 and 2 parts of chlorine, to 1 in 4 parts. We are adding the ammonia in the form of a weak solution directly in the suction well and the chlorine is added at the filter plant, using pre-chlorination. There is an interval of 20 minutes between the addition of NH_3 and chlorine.

The chlorine ammonia treatment is highly commendable and an added advance in our steady struggle for a better tasting water. In our case, however, it is only a partial solution to a perplexing problem.

E. H. PARKS:[3] The Department of Sanitary Engineering of the Indiana State Board of Health has had an opportunity to observe the action of ammonia and ammonia compounds in preventing phenolic tastes and odors after chlorination in three different plants.

The first case was studied during the early part of December, 1929. One Indiana water works draws its raw water from a stream which receives the waste from a by-product coke plant. Due to biological action and dilution, tastes and odors are observed only under certain conditions. Laboratory experiments showed that the use of ammonia in the ratio of 1.5 parts of ammonia to 1 part of chlorine would effectively prevent phenolic tastes and odors. For convenience, aqua ammonia is used, and is applied, as a solution, to the raw water in the suction of the raw water pump. The primary dose of chlorine is applied in the discharge of this pump. Conclusions as to its success must be based on laboratory data, since phenol has not been detected in the raw water since the use of ammonia was begun.

Experiments showed that ammonia as ammonium sulphate would prevent the development of phenolic tastes and odors after chlorination in the water supply at Aurora, Indiana, which is obtained from Ohio River. While records of operation on a plant scale are lacking, bench tests carried out during February, 1930, were entirely successful.

On May 1, 1930, a filter plant at one of the state institutions went into operation. The baffles in the mixing basin and the splash boards of the aerator had been generously treated with creosote. The taste and odor of the raw water were such as to render it almost undrinkable. Since experiments showed that ammonia applied as ammonium

[3] Department of Sanitary Engineering, State Department of Health, Indianapolis, Ind.

sulphate would prevent the development of the phenolic taste and odor a supply of ammonium sulphate was obtained from a fertilizer supply house. The salt was screened, mixed with powdered alum, and applied by means of the chemical feeder. While some difficulty was encountered, due to packing in the hopper of the dry feeder, operation was quite successful. The ratio of ammonia to chlorine was 1.25:1, or 5 pounds of ammonium sulphate to 1 pound of chlorine.

While for economic reasons, anhydrous ammonia would usually be preferred to ammonium sulphate the latter can be obtained easily, applied without special equipment, and can be handled by untrained operators. These facts recommend it for temporary use in cases of emergency.

JOSEPH RACE:[4] It is very gratifying to me to note the increasing interest displayed by water works officials in the conjoined use of ammonia and chlorine.

When I first used this process in Ottawa in 1916 the object was to obtain the same germicidal effect with a smaller dose of chlorine, but now it appears that this advantage of chloramine, which can only be obtained in the presence of organic matter which would absorb the chlorine, is but of minor interest as compared with the freedom from complaints that can be obtained with its use.

In this connection it is rather amusing to note that the objectionable tastes and odors occasionally produced by chlorination were at one time attributed to the production of chloramines.

Although the work of Adams on salicylic acid and its derivatives has indicated one way in which preammoniation prevents the formation of objectionable phenolic products, we have yet to isolate and identify these compounds; in fact much more research is necessary before what is now an empirical art can be placed upon a sound scientific basis.

In my early laboratory experiments with chloramines and nitrogen trichloride in 1915 no difficulty was found with the latter substance despite its well known explosive properties. Recent events, however, have clearly demonstrated that the possibility of producing the trichloride from ammonia and chlorine gas is by no means purely of academic interest.

As an example I might mention that the absorption tower, used

[4] Devonshire Hospital, Buxton, England.

for the solution of chlorine gas in a very dilute ammonia solution, was shattered by an explosion on two occasions in one plant in which an intermittent process was in operation. When operation is continuous, the risk of trichloride formation is exceedingly small, but it is as well to bear in mind that this explosive compound can be produced by the action of chlorine gas on an ammonium salt.

The chloramine process is being used more and more in Europe for treatment of the water in swimming pools for which it is the ideal process by reason of its ability to deal with the fresh pollution being constantly introduced by the bathers.

W. C. Lawrence:[5] In Cleveland we conducted experiments on various activated carbons at various rates of flow for a period of over a year and a half. We then reverted to experimental work on ammonia-chlorine treatment for taste elimination, which covered a period of nearly a year.

On the strength of our work we adopted ammonia-chlorine treatment on plant scale the first of the year.

We have not experienced a taste in six months operation, which period covers the interval when tastes have always appeared in the past.

Mr. Baylis, Mr. Howard and myself have three of the largest cities on the Great Lakes. These waters are as nearly comparable as three different supplies could be, in respect to taste producing materials in the raw water, yet three different methods of treatment are being practiced.

Mr. Baylis at the Toronto Convention, I believe, quoted the cost of carbon treatment at approximately $1.50 per million gallons. Mr. Howard, with sulphur dioxide, quoted 72 cents per million gallons, while in Cleveland the cost will be under 30 cents per million gallons.

The great value in ammonia-chlorine treatment application, besides preventing tastes, is that we find residual chlorine throughout the whole of the distribution system. The treated water after leaving the plant passes through two open reservoirs over 1500 miles of pipe mains taking four or five days to entirely empty the distribution system.

We have not encountered gas formers this year, as we previously

[5] Superintendent, Filtration and Sewage Disposal, Cleveland, Ohio.

had, especially in the far end of the pipe system. These results are confirmed by checks of the City Health Department Laboratories.

So we believe that ammonia-chlorine treatment has a great value in keeping the distribution system in good condition, besides preventing tastes, at a low cost per million gallons.

Informal Discussion

At the close of the prepared discussion of the papers on Preammoniation, certain extemporaneous statements were made that should be recorded.

Mr. Mellen of Minneapolis inquired what effect is noted from the persistence of chlorine in the distribution system. Lawrence of Cleveland stated that it served to keep down bacterial reproduction in mains and storage reservoirs.

Howard of Toronto reported that Ornstein cites instances in Germany where the delayed action of the chlorine after the ammonia treatment has so interfered with bacterial efficiency that the process could not be used because of lack of protection to consumers near the plant.

Enslow called attention to the fact that the chloramine process has been in use at Ottowa for 13 years.

Any question as to the effect of presence of higher chlorine concentration in tap water upon consumers health can be answered by a study of Ottowa conditions.

Lawrence stated that certain hospitals in Cleveland were using ammonia-chlorine combinations in post operative irrigation. He further cited certain experimental studies in the Cleveland Water Department Laboratories involving the treatment of water (artificially polluted with sewage) with chlorine and ammonia-chlorine. Bottle samples held in storage at room and ice box temperatures showed reproduction in those receiving plain chlorination and no reproduction in those receiving the ammonia-chlorine treatment.

West of New York called attention to the fact that at Lancaster the taste in the water is not due to phenol, but to organic or vegetable growth. Lawrence suggested that, for taste removal, the ratio of NH_3 to Cl must be higher than is the case where sterilization only is required.

WATER WORKS ACCOUNTING IN PRIVATELY OWNED PLANTS[1]

By P. Paul De Moya[2]

In former years too little stress has been placed on the necessity of accurate and systematic water works accounting. Before discussing the science of accounting, we must know the definition of that science, what its uses are and its functions, where and how we shall benefit from its use, and whether it is practical to use that science in the conduct of our business.

The dictionary explains that "account" means to count, to estimate, to value, to judge, to give a reckoning, to answer. "A systematized and continuous record of business dealings," may then be termed the art of accounting.

Those of us who are charged with the responsibility of operating a water works are also charged with making a reckoning or an accounting of our operations of that property. We are charged with a task of earning a fair return on the fair value of the property placed within our care. In order to bring a fair return, of necessity we must know the cost per unit of producing and delivering that product to the consumer. In our case the product is water. Not any kind of water, but, if possible, crystal clear, potable water. In very few instances, especially in Florida, can water be delivered to consumers without extensive treatment. From the time water is obtained from its source, until it finds its way to domestic consumption, its path is marked by the expenditure of money. So in order to arrive at a fair rate to be paid for the water delivered, one must know the cost incidental to its treatment and production.

Capital must be employed and invested in land embracing the water supply, as well as in pumping stations, purification equipment, garages, store-rooms, and shops. To this we must add the capital in transmission mains, distribution mains, services, meters and fire

[1] Presented before the Florida Section meeting, April 11, 1930.

[2] Local Manager, Consumers Water Company, Stuart, Fla.

hydrants. Some accurate and definite means must be employed of accounting for the tangible capital invested in the water works.

CAPITAL ACCOUNTS

The utility business is unlike many other enterprises for it deals daily with capital accounts. Each time we run a new service, or a main is extended, or a meter installed, we add to our capital investment. By a like process, each time a service or main is abandoned, or a worn out meter cast off, we affect our capital account. With almost all other businesses the tangible capital account remains quite undisturbed, month after month.

If we deal with our investment, daily increasing or decreasing it, it is essential that the capital accounts shall be kept carefully and accurately. Estimates for new installations must be carefully made out with reference to the cost of material and labor. The material is charged to the proper capital account by requisition on the storekeeper, and material cannot be taken from our store-rooms unless an estimate has been prepared and approved by the management. The labor is charged to the capital accounts through the medium of daily time tickets. In this way the daily additions to capital accounts are accurately kept. During the abandonment of tangible property the same procedure is reversed and the capital accounts credited with the original cost of the property.

With slipshod methods of charging and crediting the capital accounts a plant management can find itself with thousands of dollars more tangible property than its books record. On the other hand, it may have a "watered" property in which the value of the property is far below its recorded value. Since neither situation is desirable and reflects inefficient management, great care is taken to record accurately the daily transactions dealing with our invested capital.

It is not sufficient to group all operating revenue under one revenue or sales account. The services a water plant sells are varied. There are metered sales, flat rate sales, sales to municipalities for fire protection, and possible, sales to other water utilities, or municipalities for other than hydrant purposes.

Grouping all revenues received under a common head, does not permit analysis of individual services rendered. Just because the total gross revenue shows a sufficient margin over costs, to permit a fair return, is no reason for continuing a rate to a certain group when that rate does not result in the return of costs including a fair return.

A situation of this kind tends to penalize those who operate on the rate or rates that carry the burden that should be spread over all users of the service. With a "breakdown" of revenue accounts we are in a position to analyse the revenue derived from the varied interests who use our service.

OPERATING AND MAINTENANCE EXPENSE ACCOUNTS

We arrive now at accounting for our operating and maintenance expense accounts. The importance we place on these accounts are not overshadowed by the accuracy with which the accounts mentioned before are kept. Without the proper knowledge of operating and maintenance costs, a plant operates as a ship without a rudder. The ship's course is uncertain, the captain and crew little know where they will wind up—the end may be days off or it may be the next moment. Perhaps kind Providence will blow them away from the rocks today, only to tear the bottom out on the shoals tomorrow. We are in the same plight in operating a water plant where operating costs are not kept accurately and up to date. Without a distinct separation between operating expense accounts and operating maintenance expense accounts it is quite impossible to tell whether it is feasible to continue the use of some of the apparatus whose maintenance costs accrue often or to abandon it and replace it with apparatus whose operating costs, plus cost of retiring the old apparatus, will be less over a period of time.

In our organization we know our operating costs for each day at the close of business. Perhaps this seems needless and a waste of time, but the reasons for such a system may justify its existence and use. With records of this kind before the management, it is possible to grade expenditures to revenue received. It shows up in daily telltale figures waste and similar leaks. It permits those in charge to stop immediately needless or wasteful operating costs before they have mounted to the deplorable state. It shows the management where the idle labor is draining its revenue. It shows the cost of repairing yesterday's leak. In other words, it is a true business barometer, permitting the management to chart the business course according to conditions that arise day by day. It is the best means imaginable to stay within an operating budget. A dollar saved in operation is worth a good deal more than a dollar added to your revenue. A daily summary of operating expenses certainly helps to save operating dollars that would be lost if only a periodic report of operating expense were used.

Much discussion has gone on as what shall be defined for accounting purposes, as operating expense and what shall be maintenance expense. Both, of course, are expense accounts. The difference between these two operating cost groups has been given by a public utility authority as follows:

"The term 'Operating Expenses' includes such expenses as are necessary to—
The maintenance of the Corporate organization;
The rendering of service required or authorized by law;
The production and the disposition of commodities produced, and
The collection of the revenues therefor.

Operation

Operation involves labor, material and supplies consumed in the operating process, the replacement of which does not constitute a repair or renewal, and such other operating expenses as are not included in maintenance.

Maintenance

Current maintenance includes such expenses necessary to maintain the tangible property in a state of operating efficiency as do not result in a substantial change of identity in any particular unit placements of small parts commonly called the cost of repairs, but it does not include the cost of replacing individual structures, facilities or units of equipment or important sections of continuous structures, such as water line. Current maintenance costs are chargeable to operating expenses and wherever the word 'maintenance' is used in the definition of an operating expense account, current maintenance is to be understood.

The cost of replacing the larger units is chargeable to fixed capital, from which the cost of the property replaced must be deducted.

In order, by example, to make clear the distinction between operating and maintenance expense items, let us consider the suit of clothes which you are wearing:

The price paid by you for the suit represents your *Capital Investment* in the suit.

The sponging, pressing, cleaning and brushing of the suit are items of *Operating Expense* necessary for the fullest realization of the investment value in the suit of clothes.

Replacing buttons, sewing up rips or tears, putting in new pockets and items of expense of this character are *Maintenance Expense* and represent the *Maintenance Expense* necessary in order for you to secure a longer life and the fullest use of the investment you have made in the suit of clothes.

After the suit has been worn and successively cleaned and patched until it reaches the stage commonly referred to as 'worn out' and you then buy a new suit of clothes, the purchase of the second suit of clothes is *Replacement*, and is properly chargeable to the Depreciation Reserve, which you should have set up out of your income from day to day while you were wearing the old suit of clothes.

Any excess cost of the second suit over the cost of the first, of course, represents an Added Investment of Capital, and is properly chargeable to Capital Account, as was the purchase price of the original suit."

Our expense is divided into groups that permit all phases of operation to be individually checked and changes made in an individual phase of our operating without costly analysis that lack of "breakdown" would entail.

Water supply operation. We have a "source of water supply" operating account against which is placed cost of supplies and expense in connection with our wells.

Water supply maintenance. Against a source of water supply maintenance account is placed all expense incidental to repairs made to our wells.

Pumping-operation. The pumping operation account covers all expense occasioned in the operation of the pumping plant, such as operator's wages, labor, lubricants, lights, telephone, waste, packing and similar supplies.

Pumping-maintenance. The pumping-maintenance account includes pay-roll material and supplies incurred in repairing pumps and motors, and miscellaneous equipment at the plant, including fences, walks and pavements adjacent to the pumping plant.

Power purchased. To this account is charged the cost of electric power purchased and used for water pumping.

Purification-operation. The payroll, supplies and other expenses incurred in the operation of the purification system are charged to this account. Included would be expense of chemist's wages, of laborers, purification and filtration supplies, chemicals consumed and similar items used on the purification system, such as cleaning basins and the like.

Purification-maintenance. Into this account go all labor, materials and other expenses incurred in repairing and maintaining buildings, fixtures, and grounds devoted to the purification of water.

Transmission and distribution in operation. To this is charged the cost of superintendents and labor employed in supervising the operation and maintenance of the transmission and distribution system, the cost of maps and records of the system, the cost of stationary, miscellaneous office supplies and other incidentals, and expense of the distribution superintendent's office. It also includes the labor and expense incurred in inspecting and testing plumbing and the

fixtures of the consumers in connection with complaints and labors performed on consumers premises for which no charge is made. To this account all charges incidental to the operations of mains are made, including the labor expense caused in the inspection and patrolling of mains, reservoirs, tanks, stand pipes, service pipes and stops and fire hydrants. It also covers the cost of flushing mains and hydrants and taking street pressures. This charge also embraces the labor and material employed incidental to inspecting, testing, recovering and re-setting meters and the cost of disconnecting and reconnecting service.

Transmission and distribution-maintenance. To this account are chargeable all labor material and other expense used in maintaining the structures of buildings used the transmission or distribution of water. It covers such items as repairing leaks, removing and repairing worn sections and filling, digging, and repaving in connection with such work, repairing manholes, scraping to remove incrustations, repairs to masonry, calking, replacing decayed parts, painting, etc. It also includes all maintenance to mains, storage reservoirs, tanks, stand pipes, inlets, outlets, flushing drains and overflow pipes and control valves, guage floats, high water alarms and the like. To this add the cost of seeking and repairing leaks, replacing worn out pipe and fittings, including stop cocks and service boxes, digging and repaving in connection with such work, cleaning pipes, readjusting, painting, replacing worn gears, worn parts of meters, repairing meter boxes and vaults, renewal of worn out parts, painting, calking, digging and repaving in connection with hydrants or fountains.

Consumers expense. Under this head are chargeable all expenses that may be defined as cost for keeping records and contacting consumers in securing payment for water service rendered. It includes all expense in connection with the records of consumers accounts, accounts receivable, consumers deposits, consumers extension deposits, preparing and mailing bills, collection notices, contacts with consumers at the office counter, in connection with taking applications for connect or disconnect of service, receiving payments for bills, making refunds and adjusting complaints at the counter. It covers the cost of reading consumers meters, delivering bills and collection notices, executing collect or cut out notices, including disconnecting meters for non-payment and reconnecting them after payment of the account. It covers all collection charges incidental to collection of delinquent accounts. It is to this account to which

uncollectible accounts are charged. The rent of local offices, janitor service, telephone and vehicle expense incurred in meter reading, collection and bill delivering are charged to this account.

Commercial expense. Commercial expenses are defined as those expenses incurred with a view to securing new business. It covers newspaper advertising, advertising booklets and the cost of soliciting or developing new business.

General and miscellaneous expense operations. General and miscellaneous expenses are defined as those expenses necessary in the conducting of the water business which cannot be applied with a certain degree of accuracy to any of the distribution, utilization, consumers or commercial expense accounts provided. The principal items chargeable to this head are the salaries of agents, janitors, mail clerks, managers and stenographers. The expense of the office, such as lights, telephone service, telegraph, postage, legal fees and expenses, stationary and printing supply expenses and other associate charges, are included under this head.

General and miscellaneous in maintenance. The maintenance and repair of office furniture and fixtures such as cash registers, typewriters and billing machines are charged under this account.

Store expenses. This account includes all salaries and expenses incurred in receiving, storing and issuing supplies. Its principal items are the salary of storekeepers, truck drivers and laborers and miscellaneous expense of the storeroom such as rent, lights, water and vehicle expense.

UNIFORM CLASSIFICATION OF ACCOUNTS

I have not given all the accounts we use, but have attempted to mention those that most of you deal with daily. From the foregoing, you will see that each operation necessary, from the time the water leaves the wells to the time it is drawn from the spigot, is recorded and tabulated. With these figures on hand, intelligent operation is possible. Comparative costs can readily be made since our system is uniform and unchanging through the use of a uniform classification of accounts. The uniform classification of accounts for utilities is the basis of our accounting system. This classification is a result of the following:

At the Annual Meeting of the National Association of Railroad and Utilities Commissioners held in November, 1920, uniform systems of accounts were recommended for adoption by the State Commissions.

In 1922 this same body revised and enlarged this classification. Since that time 28 State Commissions have put the uniform classification into effect, and the remaining states are rapidly following.

The uniform classification of accounts is based on sound accounting principles, which properly record the facts and afford like protection to the public and operating utilities.

Uniform classification of accounts offers advantages to the utilities, the investor, the operator and the public in that its statements and operating reports are comparable.

The system of uniform accounting permits comparisons of operating data between water plant managements to their mutual benefit, since under a uniform classification all plants using it charge or credit the same items of expense or earnings to the same accounts as their contemporaries. Good accounting has been said to compare with history in that it is a graphic record that permits the operators of a business to have an exact knowledge of conditions prevailing and to be able to compare their efforts with prior operation. We attempt to make each entry to our books record a complete story of the transaction that will, tomorrow, add to the history of the industry.

WHAT SHOULD A WATER WORKS SUPERINTENDENT MAKE OF HIS JOB?[1]

By W. Scott Johnson[2]

This is a subject that is of vital importance to the health, welfare, and safety of every inhabitant of a city with a public water supply. A satisfactory water supply is not produced for its own sake, but for the happiness and safety of the people to whom it is supplied. The job of the water works superintendent must not only be concerned with the safety and adequacy of the city water supply, but also how thoroughly the public appreciates a safe and adequate water supply. Unfortunately, the average citizen's conception of the problem of producing a safe and adequate water supply is largely dominated by the idea of a house faucet to be manipulated at will and of a monthly water bill grudgingly paid.

As a result of considerable thought, notable progress as regards scientific engineering details of water purification and supply has been made; effort in this direction should not cease. On the other hand, looking at the human engineering side of this problem, is not the need of stimulating the intelligent support of the consumers for efficient management and operation of a water works frequently neglected, and comparatively undue stress placed, for example, on the efficiency of pumps and distribution systems?

After all, the water works superintendent is in the same position as a manufacturer who has created a necessary product of high quality for sale and who must likewise create a demand for this product at a reasonable price to the consumer. Obviously, he has certain responsibilities with regard to the quality of this product, as well as a financial obligation to the stockholders in his concern. Likewise, the superintendent must not overlook the salesmanship phase of his job or miss an opportunity to impress upon his public the importance and value of good water.

[1] Presented before the Missouri Valley Section meeting, November 6, 1930.

[2] Chief Public Health Engineer, State Board of Health, Jefferson City, Mo.

First, consider the superintendent's job from the standpoint of the production and financial responsibilities. Never before has the public been so exacting with regard to what might be termed the aesthetic qualities of a water supply. By that is meant a water free from taste, odor, color, turbidity, and hardness. The demand for improved quality in practically every known commodity has not made an exception of water. Travel from city to city has become so common that the public is well qualified by experience to judge what constitutes water of good quality. If there is any question regarding this, just allow the water from your plant to carry a slight overdose of chlorine for a day and then keep a record of the complaints. Even a clear, tasteless, and colorless city water supply, if hard, is deficient in meeting the growing desire for a reasonably soft water, that is so superior for most purposes.

Similar is the demand for a constant, undiminished supply for fire protection as well as for convenience. Within the time of our memory the public was fairly well satisfied with almost any kind of water and, in many cases, that for only part of the day. Those days are gone forever, and the water works superintendent today must not only produce a water of excellent aesthetic quality, but must supply it to the home faucet at a good pressure day and night.

Again, the last ten years have witnessed the expenditure of millions of dollars in the construction of new and improved water works systems in this country. More adequate purification and treatment plants housed in architecturally suitable buildings; larger, more extensive, and stronger water mains; vastly improved mechanical equipment; and greater storage capacities have been the trend in advancement. The maintenance and upkeep of the gigantic works, representing such a huge investment of capital, is a yearly increasing responsibility and an obligation of the superintendent to the public which has invested its money in such improvements.

ADEQUATE RECORDS NECESSARY

Adequate maintenance of the water system demands, first and foremost, better and more accurate records and accounting systems. Without such records it is practically impossible to operate a water system economically. There is no way to determine whether the plant is making or losing money, no way to assure adequate reseserv for depreciation and breakdown, and no basis upon which to plan for future expansion and development that constitutes real service

to a community, unless accurate records are kept regularly. However, there are many water plants concerning which such fundamental records as amount of water pumped and number of connections, are not known. Likewise, complete records of plant operation, particularly if water purification is involved, should be regularly and intelligently kept. Tests showing the chemical and bacteriological condition of the water, and the amount of chemicals used, including chlorine, should be matters of permanent record. However, there are many water purification plants where such an important and simple test as that for residual chlorine is made only every few days and no record kept of the results.

PROTECTING THE HEALTH OF THE COMMUNITY

Last but not least comes the water plant superintendent's responsibility for the health of the community. During the last ten to fifteen years the courts and health officials have come to the sensible view that water-borne filth diseases are unnecessary, and it is only a matter of eternal vigilance, technical training, and unbending courage to enforce health rules and regulations, that are necessary to remove forever the guilt from public water supplies as a cause. If your city water system has any sanitary defects, these have undoubtedly been pointed out to you and the city council. The courts have uniformly held that after such warnings, or because of unwarranted negligence, the city or company is liable to the extent of damages for any filth-borne diseases contracted from drinking contaminated water resulting from such defects or negligence.

A city in New York state has recently paid the cost of negligence in safe-guarding its municipal water supply; the typhoid epidemic resulting from contaminated city water cost the city $350,000. For a small part of this amount the city could have prevented the epidemic, an enormous amount of suffering, and 22 deaths. Likewise, inadequate sewage treatment or poor operation of a sewage treatment plant may result in the recovery of just damages from the city. The responsibility not only for protection of the public health, but saving the city from costly damage suits, rests squarely with the superintendent of these plants.

WHAT THE SUPERINTENDENT MUST KNOW

In brief, if the superintendent expects to make the most of his job he must know the biology, chemistry, and mechanics of supplying

a water of excellent aesthetic quality; he must understand the engineering problems concerned with assuring a constant supply at all times; he must be qualified to maintain and keep in good condition a great variety of works constituting the integral parts of a water system; he must appreciate the necessity of records and their use; and lastly, he must have a complete knowledge of the safeguards and precautions that eliminate the possibility of contamination of the supply and the resulting danger to public health. These responsibilities exist just as surely for the superintendent of the small water plant as for the superintendent of the larger plant.

Only casual consideration of these facts indicates that no single individual in the average city has a responsibility as heavy or as important to the community's welfare as the water works superintendent. There is probably no one business concern that demands as complete or exhaustive an accounting system; there are few, if any, financial institutions which have as large a capital investment under one man's management, and certainly no single individual is as responsible for the health of the community as the water works superintendent.

So much for the superintendent's responsibilities relative to the safety and production end. Let us consider the next most important factor in his job, namely, the public's or consumer's understanding of this modern business of supplying potable water. While the public has become more critical regarding the aesthetic quality of the water supply and the service rendered, there is unquestionably a complete and astounding lack of understanding relative to the actual technical difficulties and heavy responsibility which are a part of the superintendent's work. Probably the public's lack of knowledge, if not misinformation, concerning the position of the water works superintendent in a community can, to a large extent, be explained by ideas conceived years ago, when a water system consisted of a steam pump on the bank of a creek, which represented an investment of only a fraction of the cost of an up-to-date plant and where the most exacting requirement for management was a moderately good fireman. Whatever may be the cause, the public and the city officials in too many cases still view the job of water works superintendent with insufficient understanding and appreciation to make the position what it rightly deserves to be in view of its responsibilities.

WHY NOT DRAMATIZE THE DEVELOPMENT OF A WATER SUPPLY?

The idea seems to predominate that an inexhaustible supply of safe, sparkling water, available in the home at the turn of a faucet, is similar to the air we breathe—another gift that nature has bestowed upon mankind. The necessity and importance of a safe and adequate water supply and the technical qualifications needed to supervise and manage the operation of a water system are not news items that are brought to the attention of the citizens daily or more often, as is the case with many other commodities and services less essential. In competition with other highly advertised commodities, is it any wonder that the municipal water system retains a very obscure place in the public mind and, consequently, receives slight consideration or thought? No attempt has been made to dramatize for the average citizen the difficulties and scientific study expended toward perfecting water purification practice. In other words, the salesmanship end has been sadly neglected. This, I believe, largely accounts for the indifferent attitude toward the superintendent's endeavors and the lack of consideration the utility receives. It would be a conservative statement to say that the average water works superintendent receives considerably less remuneration than the average banker or doctor. The city officials themselves, amenable to the demands of their public, in most cases are no better informed, or have little more interest in, and knowledge or appreciation of, the water works superintendent's value. In most cases the superintendent of a privately owned water plant is an exception. His employers are usually men of wide experience in the water works field, who appreciate the value of an efficient superintendent and pay him accordingly.

If this is the existing condition, and, with notable exceptions, I believe it is, why is such an attitude allowed to exist and who is responsible?

The average citizen knows practically nothing about the purpose, methods, and difficulties of water purification and supply. However, the technical man, concerned with the problem of devising the most efficient machine for performing a feat of vital importance to the safety of the public, becomes critical of the lack of support from the public to whom the entire plan is a mystery. A little more attention to the human engineering phase of the situation, the enlistment of the coöperation of people as well as machinery, would produce the desired results.

I do not believe that, today, there is a single commodity, and water is no exception, which can be sold to the public simply because it is of excellent quality. The term "sold" is used not only in the sense of barter, but also to mean enlightening the public so that an understanding and appreciation of the worth exists, as well as simply a desire. That such an accomplishment is well within the realm of possibility, even regarding a commodity less essential than water, is evidenced by numerous examples. The average citizen knows ten times more about the technique of the moving picture business than the water supply business—a credit to the publicity work of the moving picture business. However, familiarity in this case in no sense breeds contempt; to the contrary, it has developed the sale of this industry to the people. We are not only air-minded, but movie-minded. Would it not be possible to secure some place in the public attention and mind for the remarkable feats and skill necessary to produce a water supply?

If the city officials and the public have failed to keep step with the greater responsibilities of the present day superintendent and the problems of water supply, it is largely because the superintendent has failed to realize the necessity of selling to his public this commodity. If the water works superintendent makes the most of his job, he must be concerned not only with the quality of the product and its proper distribution, but also the most important problem of salesmanship. Satisfactory understanding by the public concerning what their public water supply really is and means to them will create support, and even demand, for further improvements in the system and management. This should be as much the responsibility of the superintendent as any of the production problems. Today the water works system is one of the largest business concerns in the city, if not the largest, under one management. Water is the most indispensable and essential product for sale in the whole community which costs the citizen stockholders money to produce. It is only common sense to believe that a public which really has an appreciation of a superintendent's responsibility and the importance of an adequate water system will firmly support the utility.

It is becoming more essential daily that the public understand the vital importance of governmental agencies in protecting and controlling the health and welfare of every individual. Whether it is the health department, the water department, or the educational department, etc., its satisfactory and effective functioning under the

pressure of modern civilization is essential and crucial to our welfare and very existence. Picture the catastrophe to health, business, and property in any of our cities if the water supply would fail for even so short a period as twenty-four hours. The loss, without exaggeration, would probably amount to thousands of dollars and possibly many lives. The water works superintendent's foresight and skill stand between the public and such an occurrence. The public not only should be acquainted with the vital importance of such governmental agencies, but it is an obligation of those in authority to spare no effort and plan to enlighten the uninformed and, therefore, unappreciative.

We have all witnessed, on repeated occasions, the effectiveness with which the public has been sold on the value of a particular face powder, tooth paste, cigarette, or automobile, and such improvements as a state highway system or hard sufaced roads, state parks, or a new jail. Is it unreasonable, then, to believe that a more complete and sympathetic understanding of its own city water system, the product of which is a daily necessity to life and health, would be lacking on the part of the pubilc, provided its importance and value were thoroughly known? Of course, it must be realized that, while the superintendent can do much in this direction alone, he must not fail to enlist the support of the numerous unofficial organizations in every community, which can be of material assistance. The efforts of such organizations in dealing with the public are always very effective and of great assistance. The solution of human engineering problems requires a no less adequate plan and sufficient time than other engineering problems. The methods and means of approach must be well conceived and the plan put into operation long before tangible results are expected.

However, if the superintendent is not vitally concerned with making his job what it should be, he may be sure no one else is, and it rests entirely in his hands to sell his services and commodity to the public at their true value. Failure in this respect constitutes his own loss as well as a loss to the public, which, unfortunately, at the present time is viewed by the latter with exasperating calmness. It is, perhaps, not too fanciful a prophecy that we may some day witness public opinion, of its own volition, demanding the very improvements which the superintendent recommended and should have successfully secured largely through his own efforts. Such a step will be a sad reflection on the water works profession, and might lead to unfortunate results.

The importance of effective salesmanship is undoubtedly appreciated by many superintendents. However, observations indicate that this number is entirely too small, and far too many are failing to realize the necessity of planning this phase of their work as carefully as the production end. Needless to say, adequate technical training, business sense, and sales ability are essential to devloping an understanding by an enlightened public. Selling a product is no longer possible without a thorough and complete knowledge of the commodity. Therefore, first and foremost, the water works superintendent, himself, must be thoroughly trained and informed regarding his work. Then he is in a satisfactory position to convince the public. Unfortunately, water supply and purification is perhaps not a subject that strongly appeals to the sensational interest of our public; however, this only stresses the need for greater endeavor. The fact that some superintendents have succeeded in their endeavor adds precedent and courage to those who wish to, and must follow.

The job of the water works superintendent has all the potential possibilities to make it one of the most important and responsible positions in the community. The degree of success attained depends on none other than the profession itself, and, particularly, the aggressiveness shown in attaining personal qualifications essential to any scheme for successfully enlisting enlightened public opinion for adequate support. Active interest in and support of the various national and state water works organizations is undoubtedly a step forward. The water works profession needs organization today, not only for informational purposes, but also that its relation and importance to the public can be established in the most forceful and effective manner possible. I believe it is no small part of a superintendent's duty to be constantly on the alert to improve his own knowledge, and to find ways and means to impress his public with the vital and important nature of his work to the safety and continued prosperity of the entire community.

In conclusion, I wish to emphasize again that the degree of success attained by the water works superintendent in his job is directly proportionate to his ability not only to manage and operate the water works system to the best advantage of his community in every respect, but also to create a public belief in, understanding of, and demand for, a water system and a superintendent of that system, that will serve the community's best interests.

TASTE AND ODOR TROUBLES IN THE MINNEAPOLIS WATER SUPPLY[1]

By Frank Raab[2]

The production by filter plants of a water that is not only safe bacterially, but also satisfactory and palatable for drinking purposes has given deep concern to many a filter plant superintendent during recent years. The taste and odor problem is steadily assuming greater and more serious proportions. Plants large and small are fairly haunted by taste and odor problems during certain months of the year. And in not a few instances has the elimination of these tastes and odors, for a time, baffled the best water works talent. It seems that the tastes and odors caused by algae are more troublesome than those caused by trade wastes. Tastes and odors, and in a great majority of cases they are only odors, are of a great variety and the treatment that is a remedy in one place may prove a detriment in another.

Minneapolis takes its water supply from the Mississippi River which, with its tributaries, has its source in many lakes and great stretches of swamp lands in northern Minnesota.

During the last seven or eight years Minneapolis has had more or less complaint about unpleasant odors in the finished water during fall months. This odor usually made its first appearance in the distribution system some six or seven miles from the filter plant. It first developed in a certain section of the city from which it moved outward away from the plant and always disappeared last in the remotest sections of the distribution system. The same odor recurred for four or five successive years. The writer always recognized it immediately upon its appearance, which was usually during the latter part of August or the early part of September when the water temperatures began to change. The odor mildly resembled that of iodoform. Hardly two people agreed upon its identity although it was

[1] Presented before the Missouri Valley Section meeting, November 5, 1930.

[2] Chemist and Bacteriologist, Fridley Filtration Plant, Minneapolis, Minn.

the same wherever it appeared and varied only in degrees of intensity. Not infrequently some members of the same family refused to drink the water while other members noticed nothing very abnormal about it. All attempts to produce this odor artificially in the laboratory failed.

In the fall of 1928 a new menace appeared for the first time. Over night the filters became green as if an insoluble pigment had been dusted over the surface. These floating algae proved to be Aphanizomenon. At the time these organisms imparted no odor to the water, but interfered seriously with the length of the filter runs which were reduced by fully 70 per cent. Many of these algae passed the filters and appeared in the finished water. Three and four times the normal dose of alum did not coagulate them out. Laboratory experiments showed that 1.5 to 2.0 p.p.m. of chlorine killed and disintegrated them in about two hours. The entire trouble did not last for much more than a week when it disappeared as suddenly as it had come.

In the fall of 1929 Anabaena appeared on the filters very suddenly. Over night the filters a become as green as a lawn. A very strong moldy odor accompanied them. Large doses of alum gave little or no relief. The very disagreeable moldy odor spread throughout the plant and soon appeared in the finished water over the entire city and the complaints that reached us over the telephone were not the least of our worries.

After a few days pre-chlorination in amounts up to 14 pounds per million gallons was begun and the moldy odor disappeared from the finished water. If anything the water had a slightly bitter taste. But we did not have sufficient equipment and were forced to decrease the chlorine dose to 10 pounds per million gallons and as a result the odor reappeared in the finished water and remained there until it disappeared from the river. An unfortunate incident was the meeting of the American Public Health Association which was held in our city about the time when the odor was at its worst and the remarks that were passed about our water were no credit to any water works official.

During the months of July and August, 1930, Aphanizomenon appeared on the filters on two occasions, but no odor accompanied them. In the early part of September they appeared for the third time accompanied by a highly disagreeable moldy odor which was not affected by 2 grains of alum per gallon and 11 pounds of chlorine per million gallons.

CHLORINE-AMMONIA TREATMENT

Several plants in the state controlled algae odors effectively with chlorine-ammonia treatment and upon the suggestion and with the cooperation of the Division of Sanitation of the Minnesota Department of Health, this treatment was installed in our two plants. Chlorine and ammonia were added to the raw water respectively in ratios of 2:1 to 5:1. The chlorine was finally raised to 17 pounds per million gallons, but the water showed no improvement as far as odor removal was concerned. Chloramines appeared on the filters in amounts up to 0.9 p.p.m. as measured by the o-tolidine method. No chloramines passed the filters. The alum was increased to 6 grains per gallon in the hope of carrying down the algae; but the algae resisted the large dose of alum as well as the high dose of chloramines and continued coming through the filters in great numbers.

This treatment showed no improvement after 48 hours when the chlorine application was changed from the raw to the filtered water in the same ratio and in amounts up to 17 pounds per million gallons. Water two hours after leaving the plant contained 1.90 p.p.m. of residual chlorine and chloramines. The complaints that reached the plant can be imagined. Gold fish and minnows in the stores where they were offered for sale, died by the hundreds. But the moldy odor continued as marked as ever. Very few people drank the city water and all springs, park wells and artesian wells were worked overtime to furnish water to a grumbling public. Some of the park wells were lined with cars for a distance of two blocks as late as ten o'clock at night all waiting their turn to fill jugs, bottles and other utensils with drinking water. Commercial spring water companies took no new customers unless the latter were content to wait two weeks for their first delivery.

After eight days of unsuccessful odor removal, the chlorine-ammonia treatment was abandoned and both plants returned to a dosage of 3 grains per gallon of alum and 11 pounds of chlorine added after filtration; but the odor still persisted. Any one crossing the Mississippi on a bridge 75 feet above the water could not help but notice the moldy odor that came from the river.

PRECHLORINATION

At this stage pre-chlorination was begun at the Fridley plant. At first 12 pounds of chlorine were added per million gallons. This

was soon increased to 15 and finally to 18 pounds. Four pounds were added in post-chlorination. When this water came through the plant it showed a very marked improvement. Even with 12 pounds of pre-chlorination the moldy odor had practically disappeared. With 18 pounds the water coming onto the filters contained never more than 0.20 p.p.m. of residual chlorine. The filter effluent contained from 0.02 to 0.03 p.p.m. of residual chlorine. After two days of try-out at the Fridley plant pre-chlorination was likewise installed at the Columbia Heights plant with the same gratifying results. Soon after pre-chlorination was begun there was a marked falling off in the number of algae that passed the filters and the filter runs increased from an average of 8 hours to an average of 28 hours.

After a week of pre-chlorination at both plants the moldy odor had practically disappeared from the entire distribution system. Careful checks bore this out, although it was still hard to convince the people that a big change had come about in the water that reached their taps. Six weeks afterwards, when pre-chlorination had been discontinued and the odor in the raw water had abated completely there were still some people who insisted that they could not drink the water on account of its disagreeable odor.

No doubt the higher oxidizing power of chlorine over chloramines was responsible for the removal.

It is not certain that Aphanizomenon were responsible for the moldy odor, although they far outnumbered all other algae in the water at the time. They had appeared twice within three weeks without being accompanied by any disagreeable odor. Repeated attempts to produce this odor in the laboratory by permitting quantities of Aphanizomenon to die and disintegrate failed to produce a moldy odor.

The writer is of the opinion that 21 and even 24 pounds of chlorine might have been used per million gallons of raw water without having to resort to de-chlorination. No aeration was attempted except on a laboratory scale where some improvement in the raw water was observed. Aeration is now being installed in the Fridley plant.

Pre-chlorination in doses of 12 pounds per million gallons and more completely eliminated the profuse anaerobic gas formation[3] which is so annoying in bacteriological analysis and which at times

[3] Raab, Anerobic Lactose Fermenting Spore Bearers in The City of Minneapolis Water Supply, Jour. Amer. W. W. Assoc., 6: 10, November, 1923, pp. 1051–1055.

affects practically all the 10 cc. tubes inoculated with finished water. Anaerobic gas formation is rare in the raw water. The presence of these organisms and their misleading fermentations have been pointed out in a work that was done at the Columbia Heights Filtration Plant, where an attempt was made to eliminate this profuse gas production by a modified media.[4]

SUMMARY

The chlorine-ammonia treatment did not remove the moldy odor from the Minneapolis water. Pre-chlorination removed this odor to a degree where it was no longer observed by the average consumer. Pre-chlorination increased the filter runs from an average of 8 to an average of 28 hours. Pre-chlorination completely eliminated anaerobic gas fermentation in the finished water.

[4] Janzig and Montank, The Elimination of False Presumptive Tests, Jour. Amer. W. W. Assoc., 20; 5, November, 1928, pp. 684–695.

TURBIDITY, PLANKTON AND MINERAL CONTENT OF THE DETROIT WATER SUPPLY

By Bert Hudgins[1]

Artificial purification of water has made rapid progress in the past few decades. Treatment to make water safe from pathogenic bacteria from sewage, and to settle its turbidity and make it clear for use, are the main aims in the purification process. It has been found in the operation of the filter plant that the process is greatly affected by turbidity, plankton, and mineral content of the raw water used. It is the purpose of this paper to show the importance of these three factors in the purification of water at Detroit, Michigan.

The Great Lakes are the source of the Detroit Water Supply. The intake is located at the head of Belle Isle in the Detroit River, and the outlet of shallow Lake St. Clair. The latter, a part of the straits connecting Lake Huron and Lake Erie, occupies 460 square mile, and contains the large delta of St. Clair River. Lake St. Clair has an average depth of 10 feet, and at no place is it more than 22 feet deep. The bottom is muddy and easily stirred up, and the shores are polluted to a considerable extent from habitations along them. However, the volume of water is practically unlimited as far as a source of water supply is concerned and it is flowing, although slowly (figure 1).

The turbidity of the water in the Detroit River is generally low because of the settling effect of Lake St. Clair and the larger lakes above. The Detroit Filtration Plant deals with a turbidity of 35 parts per million. Water for domestic use ordinarily has a turbidity of considerably less than 5 p.p.m. People like a water that appears clear.

Where great amounts of sediment must be removed in a purification process as at St. Louis, large and expensive settling basins are required, and these must be cleaned often. Some notable contrasts in

[1] Head of the Department of Geography and Geology, College of The City of Detroit, Detroit, Mich.

the Detroit and St. Louis purification plants may be shown in this regard, in spite of the fact that the Detroit system supplies 1,900,000 people, and that of St. Louis only 900,000. The Detroit Plant has a total coagulation and sedimentary basin capacity of 29,000,000 gallons, with an average 2 hour period for water passage, and the sediment is removed about once a year with teams and scrapers at small cost. The St. Louis Plant has a total coagulation and sedi-

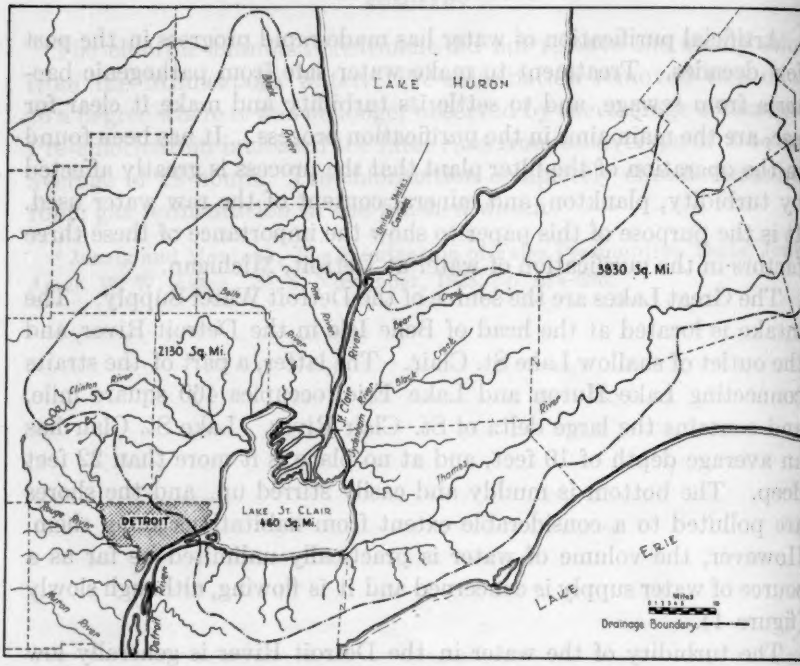

Fig. 1. Map of the Straits, Showing the Location of the Intake for Detroit's Water Supply

Note numerous tributaries that drain to the straits, and the size of the St. Clair delta.

mentary basin capacity of 295,000,000 gallons, with a 25-hour period for water passage, and sediments are removed at the rate of 200,000 tons each year, costing $10,000.

In 1929, St. Louis used 1.26 grains per gallon of aluminum sulphate as coagulant, while Detroit used 0.84. This difference is largely due to the difference in turbidity, and the economy in having a low turbidity water is seen when we note that the Detroit

rate of alum use is but two-thirds that of St. Louis, and the expense of alum alone is about $400 per day at the Detroit plant. Detroit, then, has a source of water which contains enough turbidity to facilitate coagulation, but not enough to make it a costly item in filtration.

The most important consideration, however, in regard to turbidity in the Detroit water supply, is that it is an indicator of pollution. In streams such as the Ohio at Cincinnati, or the Missouri at St. Louis, high turbidity follows rains and is an indicator of flood waters, the suspended matter having been obtained from surface and tributary wash into the main streams. It is not always an indicator of pollution in such places. On the other hand, turbidity in the Detroit water from the shallow Lake St. Clair may be caused by winds which stir up the sediments of the Lake bottom, or turbidity may result from the flushing of tributaries in the built-up area surrounding the lake, or it may result from the melting of ice which has carried pollution and sediments from shore to positions out into the lake. In any of these cases the turbidity is likely to be due to much pollution. Records show that an increase in bacteria content nearly always accompanies an increase in turbidity at the Detroit Plant. Operators at the plant recognize this fact, and in their daily routine use turbidity as a guide for treatment of the water. When turbidity increases then pollution usually increases and the alum dose is increased to get settlement. Turbidity rarely runs higher than 400 p.p.m. in the lake water. Therefore, since the actual results of the laboratory tests of water for bacteria and B. coli are not known for 12, 24, and 36 hours after the samples are collected, turbidity is a particularly helpful indicator. High tubidity may be caused by rain storms, thaws, or break-up and melting of ice in the spring; but high wind velocities are perhaps the most common cause of irregularity in turbidity of the raw water. On April 14, 1928 (figure 3) the wind velocity rose to 40 miles per hour from 2 to 4 P.M. Turbidity immediately rose from 20 to more than 100 p.p.m. Bacteria and B. coli peaks followed immediately, and extra alum dosage was applied to get coagulation and settlement. It should be noted that, in this case, the high wind velocity might have been used as an indicator of coming pollution, for it preceded the B. coli peak by about four hours.

The problem of dealing with plankton in the water at Detroit is quite different from this problem in the cases of other large cities which get supplies from smaller lakes and ponds and the larger rivers.

Plankton is considered as the whole or parts of minute animal and plant life, partly floating and partly attached, without particular means of locomotion. By decay or increase in quantity plankton may give odor and taste to a water. Chemical action favored by forms of plankton may cause incrustation of water mains; or plankton may gather on filter walls and produce a tremendously offensive odor; or it may collect in filter beds to slow up the rate of filtration and necessitate the frequent cleaning of the filters. Sometimes

TABLE 1

Genera of plant and animal life in the Detroit River compared with those of elsewhere

GENERA OF PLANT AND ANIMAL LIFE FOUND IN RAW WATER AT DETROIT[1]	GENERA OF PLANT AND ANIMAL LIFE THAT GIVE MOST TROUBLE IN WATER[2]
*Asterionella	Asterionella
Synedra	Conferva
*Fragilaria	Fragilaria
Stephanodiscus	Oscillatoria
Cyclotella	Spirogyra
Pediastrum	Chara
*Anabaena	Anabaena
Dinobryon	Dinobryon
*Synura	Synura
Uroglena	Navicula
Ceratium	Beggiatoa
Vorticella	Cladophora
*Chara	Crenothrix
Rotifer	Clathrocystis
Cyclops	
Hydra	

[1] LeMarre, R. J., Bacteriological Examination of Detroit Water (MS).
[2] Mason, W. P., Water Supply, 4th Ed., p. 325.
* Plankton in the Detroit Water Supply that have been known to give trouble elsewhere.

algae adhere to the interior of the water mains and diminish, if not actually stop, the flow of water.

Many methods are now employed in dealing with plankton, among which are treatment with copper sulphate and other minerals to prevent growth, to aerate the water, or to cover the reservoirs for preventing sunlight from favoring growth. The lake water has been called "plankton poor" as compared with water supplies of other cities. In addition, reservoirs for the retention of water in the De-

troit plant are so small that algae in particular are not favored in their growth, a fact which will be brought out later.

A comparison in table 1 of the genera of plant and animal life found in the lake water with the list of the forms which give the most trouble in waterworks plants of the country, reveals a scarcity in the Detroit water of those usually harmful.

The only genera represented in the list from the Detroit River water supply which have been known to be harmful in other plants are Asterionella, Fragilaria, Anabaena, and Synura. At Lake Cochituate of the Boston Water Supply, Synura causes a fishy odor 7.7 percent of the time in spite of the fact that this reservoir is held only as a reserve supply and seldom used.[2] At Holyoke, Massachusetts, Chara has at times caused so strong an odor of hydrogen sulphide as to render the water unfit for drinking or laundry work.[3] Fishy odor caused by Asterionella has been observed in the water supply at Troy, New York.[4] Of the genera which have given trouble at the cities mentioned, Detroit has Synura and Asterionella. These may give trouble as the Detroit water system grows older, but the chances are that they will not, because of the short length of time the water remains in settlement basins at Detroit as compared with periods of settlement elsewhere. It has been previously pointed out that the Detroit filtration plant has only a two hour settlement period, and relatively small basins.

The plankton counts by months as presented in table 2 in the Detroit water supply show Asterionella to be the most important single genus at the time of maximum numbers. There has never been complaint, however, of this genus in the Detroit supply.

The protozoan, hydra, is the only form of plankton which has ever given filtration officials any concern at the Detroit plant. Its coming is seasonal and very regular for a few days in mid-November and again in April, properly timed and probably associated with "turn-over" of the waters of Lake St. Clair. The temperature, 39 degrees Fahrenheit, the point of greatest density of water, is passed on the dates given, (figure 2). According to filtration records, the coming of hydra has been quite regular since the beginning of filtering in 1923. At the periods of their coming they collect in such quantities that their death and decay forms a pinkish coating on the

[2] Whipple, G., Microscopy of Drinking Water, p. 65.
[3] Op. cit. p. 54.
[4] Mason, W. P., Water Supply, p. 326.

filter walls and a jelly-like material that clogs the filter walls and gives a fishy odor, if the filters are not washed often. After the first excitement of filtration officials at the coming of hydra in 1923, not much attention has been given to this plankton. Filter walls are cleaned carefully during two weeks in April and likewise during two weeks in late November. It reduces filter rates, which makes the

TABLE 2

Plankton counts by months

Monthly average, maximum and minimum number of micro-organisms, and the percentage of which certain organisms were found in raw water at Detroit.[1]

	Number of organisms per cubic centimeter			Per cent of each form						
	Average	Maximum	Minimum	Asterionella	Synedra	Tebellaria	Fragilaria	Miscellaneous diatoms	Flagellates	Miscellaneous organisms
1928										
July	200	416	36	14.5	19.6	7.7	9.8	23.7	7.9	16.8
August	65	164	27	2.1	14.2	2.7	5.3	18.5	28.3	28.9
September	89	193	33	0.8	7.0	3.7	10.9	18.5	38.1	21.0
October	172	315	70	4.5	3.7	4.1	17.7	10.7	43.9	15.5
November	280	754	72	7.6	2.3	8.7	36.7	15.4	18.6	10.7
December	207	674	66	8.7	2.6	16.8	34.6	16.6	5.8	14.9
1929										
January	120	294	49	13.0	4.8	23.0	13.2	17.0	2.0	27.0
February	144	240	61	22.3	4.3	22.1	16.0	7.6	1.5	25.2
March	321	928	68	14.7	4.9	18.4	23.0	17.0	3.9	18.1
April	567	964	216	13.3	12.0	19.7	14.9	20.2	4.0	15.9
May	795	1,116	436	12.8	12.3	11.5	11.9	17.6	17.5	16.4
June	884	1,576	250	19.5	11.3	8.8	5.6	11.3	9.9	33.6

[1] 77th Annual Report Board Water Commissioners, 1929, p. 30, Detroit, Mich.

treatment of water more costly. In the spring of 1926 the length of the filter run was reduced one third by hydra.

On the whole, Detroit is favored by a water supply which is free from odor, taste, or great expense resulting from the presence of plankton. It does not face a great expense in building and covering reservoirs to shut out sunlight and thus lessen the growth of algae, and to prevent pollution from the air and other possible sources during the retention of the water. Detroit does not have the expense of

the application of chemicals to combat algae or the shutting off of parts of the source of water to prevent certain plankton from entering as is the case with the Boston supply. Lake St. Clair is "plankton poor" according to the Michigan Fish Commission, which has shown that the plankton content would have to be increased 30 times to make it rank with the "plankton rich" lakes.[5]

Hydra and Chara forms are found in Lake St. Clair and are often attached to the bottom or to objects in the water. Since the lake is shallow enough to permit light to penetrate its depth, and since currents from the delta mouths of the St. Clair River are distributed quite throughout the lake, it is likely that these somewhat attached forms of plankton are more favored in this lake than the free floating genera. Water "turn-over" comes at the two seasons of the year mentioned, loosens hydra and brings it in quantity to the water supply.

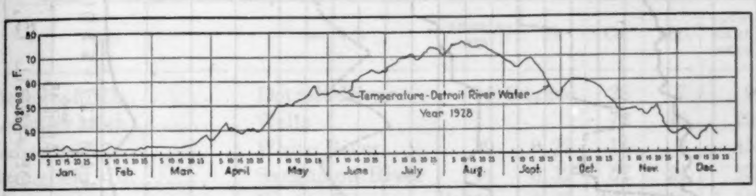

FIG. 2. TEMPERATURES OF THE DETROIT RIVER WATER FOR 1928

Since water is heaviest at 39°F., there is water "turn-over" in Lake St. Clair when the 39°F. mark is passed in Spring and Fall.

The great quantity of flowing water in the straits favors no plankton troubles. Algae grow best in quiet water; most of the large cities that do not have trouble with plankton get water supplies from the straits or lake sources as does Detroit. Cities troubled with plankton in the water supply usually have shallow inland lakes and ponds as a source of supply, or have large settling basins where water is detained for a considerable time before use. With the exceedingly great quantity of clear flowing water supply, Detroit does not require settling basins, and, therefore, has little trouble with plankton.

The influence of the mineral content of the Detroit water supply is negative. Having a moderately soft water, the city is not handicapped by the inconvenience and expense of softening for industrial

[5] Reighard, J. E., Bul. Mich. Fish. Com., No. 4, p. 31.

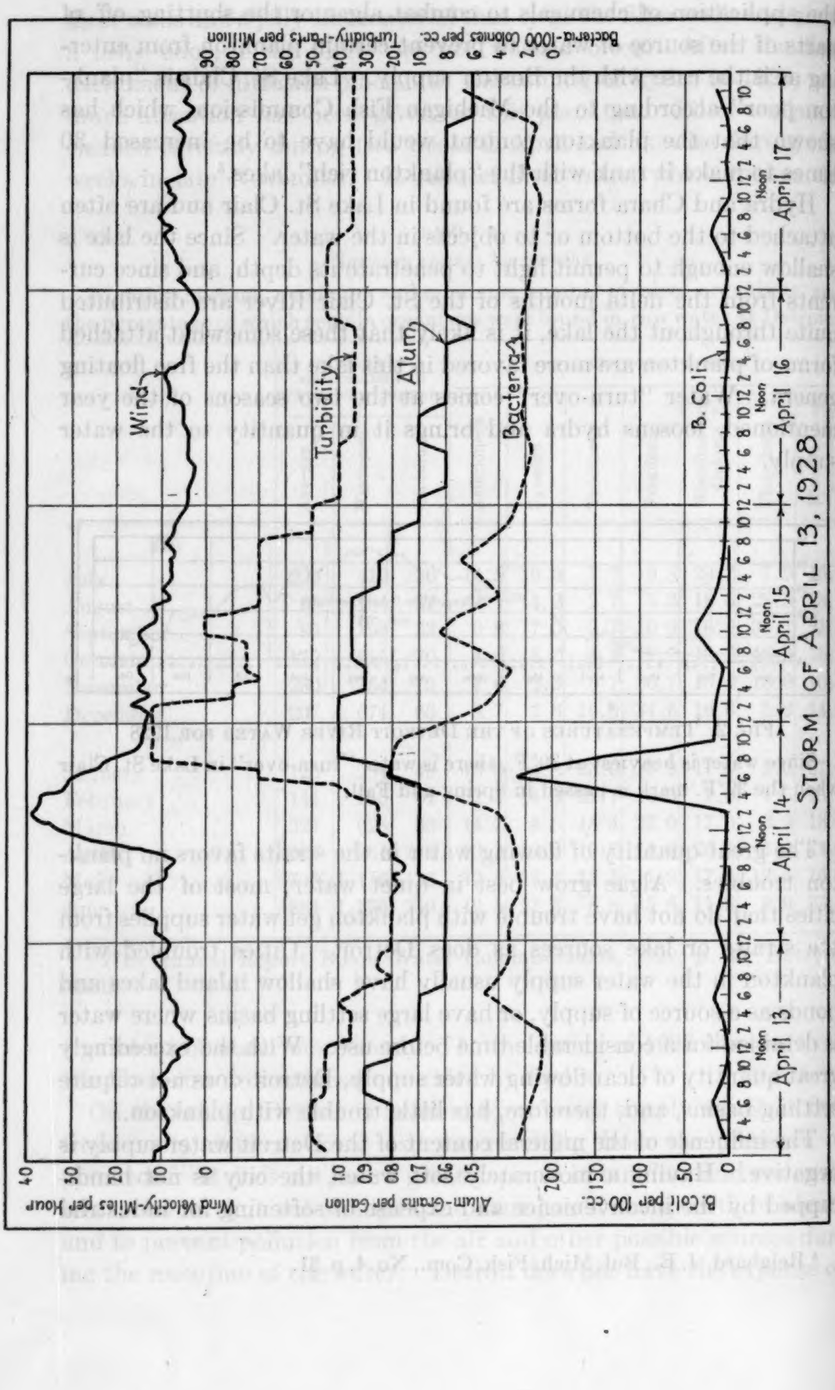

Fig. 3. Storm of April 13, 1928, Showing Increased Wind Velocity, Followed by High Turbidity, Bacteria and B. Coli

and commercial use. In table 3 the Detroit water is compared with others.

If one should judge from the maps showing hardness of the waters of the United States and of Michigan, it would be expected that Detroit would have a water classed as hard, but this is not the case, since the Great Lakes are large in volume, and slow flowing, both of which give an opportunity for minerals to precipitate as does sediment, so that water taken from the strait as in the Detroit River is fairly soft.

Detroit, with a water of 96 parts per million of hardness, and no iron content, saves hundreds of thousands of dollars each year which it would have to spend if the water supply were as hard as that of inland Michigan cities.

TABLE 3

Characteristics of water supplies of representative cities

CITY	SOURCE	TURBIDITY	Fe	Ca	Mg	TOTAL HARDNESS
Detroit, Mich.	Detroit River	14.5	trace	28	7	96
Lansing, Mich.	Wells			72	28	291
Indianapolis.	White River	39	0.22	14	7	450
Springfield, Ill.	Sangamon River	74	0.32	52	24	276
Waco, Texas.	Brazos River	1,462	0.26	121	19	1,162
Bethlehem, Pa.	Lehigh River	14	0.10	14	6	95

Many of the industrial plants of Detroit, however, are now beginning to realize the economy of introducing systems to reduce further the hardness of the water. Among these are the Detroit Edison Plant, Henry Ford Hospital, Ford Factory, the Detroit City Gas Company, and nearly all laundries and ice plants which require a complete removal of hardness. A municipal plant can soften a 250 part per million water fit for boiler use, and laundry and household use for about $16.00 per million gallons.[6] Mr. Hoover of the Columbus Ohio Plant estimates that municipal softening amounts to about 10 cents per 1 part per million for 1,000,000 gallons of water. Since the Detroit supply has a hardness of 96 parts per million, and 250,000,000 gallons are used daily, the cost for softening it would be about $2500 per day. It can thus be seen that the moderately soft nature of the

[6] Municipal Water Softening, Eng. Bul. No. 15, Michigan Dept. of Health, Lansing, 1928, p. 12.

Great Lakes supply of water, places Detroit at a distinct advantage. It must also be remembered that Detroit filters its water supply, and in so doing a small amount of hardness is removed. For industrial and commercial purposes the Detroit water supply ranks well with the soft waters of eastern cities, regardless of the fact that the waters of the interior of the country are generally hard, another advantage of taking a water supply from the Great Lakes where sediment is low, the water is moderately soft, with a large volume and slow flow.

DISCUSSION

PRECHLORINATION IN RELATION TO FILTER PLANT EFFICIENCY

The carefully conducted and controlled study of the prechlorination[1] of Ohio River water at Cincinnati furnishes conclusive data upon the value of this treatment in reducing high bacterial loads upon rapid sand filters. One important conclusion in this paper is that the prechlorination dose should be regulated to prevent residual chlorine concentration of over 0.05 p.p.m., in the water applied to the filters; otherwise the chlorine destroys the filamentous organisms on the sand grains and is said to reduce the efficiency of filtration.

Were prechlorination practiced merely as a disinfecting procedure, and were all coagulation basins sufficiently large to provide a considerable reaction period, then the manipulation of the dose, to prevent excessive concentration of residual chlorine in the applied water, would not interfere with effective disinfection. There are many existing water purification plants, however, where the detention period in the basins is as short as one or two hours and yet where excessive numbers of bacteria are present in the raw water. It is doubtful, therefore, whether satisfactory disinfection may be secured with prechlorination doses sufficiently low to insure the presence of only small quantities of residual chlorine in the applied water. On the other hand, much larger doses of chlorine would be permissible from the standpoint of tastes, due to the effective dechlorinating ability of filter beds. It is obvious that the use of prechlorination to control algae in coagulation basins, the growths of slime in filter beds, or to improve the coagulation of water containing iron or sulphur compounds, etc., requires the use of relatively large chlorine doses, and the presence of residual chlorine in the water reaching the filters. It is very important, therefore, that the apparent reduction in the efficiency of filtration by chlorine be given very careful consideration.

The growth of filamentous organisms in filter beds naturally will be destroyed by appreciable quantities of residual chlorine, and during

[1] Journal, January, 1931, page 25.

the period of their destruction the efficiency of filtration might be lowered, as indicated by the results secured in Cincinnati, Cleveland, and during the first portion of the trials with prechlorination at Sandusky, Ohio. Following the destruction of filamentous organisms, however, the biological slime on the sand grains will be destroyed and removed by washing. Observations at Toronto and at several filtration plants in New York State, and at Sandusky, O., during the latter portion of the trials with prechlorination, indicate that, following this removal of biological growth, the sand grains become coated with a deposit of aluminum hydroxide floc, which restores the efficiency of filtration. These observations, therefore, indicate that prechlorination may be practiced with the use of large doses without any permanent detriment in the efficiency of filtration. In fact, the use of large doses enables filter beds being effectively maintained even when seriously polluted waters are filtered, as at Rensselaer, N. Y., where prechlorination has prevented the development of slime growths in the filter bed, and has prevented sand bed shrinkage and has enabled the beds being washed with low rates of wash water flow. It is also obvious that the permissible use of relatively large prechlorination doses in filter plants will enable this treatment being used for various purposes without very careful control of the dose, especially when the filters are so effective in removing residual chlorine from the applied water.

It is hoped, therefore, that the study in Cincinnati will be continued and that the prechlorine doses applied to the water flowing to one of the filter units will be adjusted so as to insure the presence of considerable residual chlorine in the applied water, and that these trials will be continued for a sufficient period to ascertain the results secured following the destruction of any biological film which may be present on the sand grains at the beginning of the experiment. The conclusions from such carefully controlled studies would go a long way in furnishing positive evidence as to this very important aspect of prechlorination.

Charles R. Cox.[2]

The effects of prechlorination in the experiments conducted by the authors are most interesting and valuable, especially since the comparisons are made from a parallel flow arrangement. The authors are to be congratulated on an excellent piece of work.

[2] Assistant Sanitarian, State Department of Health, Albany, N. Y.

On the Pacific Coast bacterial overloading has not as yet given cause for concern, but overloading due to heavy algal growth and the attendant mud-ball formation in filters has caused considerable difficulty.

Messrs. Streeter and Wright have pointed out the inability of prechlorination to lengthen filter runs when the chlorine is added after coagulation. This is an important fact that has not been sufficiently stressed in the past. It is our observation that chlorine applied in quantities up to 1.0 p.p.m. immediately before filtration does not increase efficiency and in fact tends to decrease the length of filter runs, while chlorination ahead of coagulation results in longer runs and a better condition of the filter bed.

Whether the reactions responsible for these results are chemical, biological or physical in nature is somewhat in doubt. It is my belief that some small motile, gelatinous organisms are responsible which if not killed before the addition of the coagulant are active enough to elude the entangling floc and therefore do not settle out; organisms such as the protozoan "Monas" exhibit this ability.

Messrs. Streeter and Wright state that for 6 of the 15 months the filter receiving the chlorinated water gave longer runs than the filter receiving unchlorinated water. They do not state, however, whether this period occurred during the summer or winter season. If the longer runs occurred during the winter season when biological acitvity is at an ebb would not this be contributory evidence in support of the aforementioned theory?

Ralph A. Stevenson.[3]

[3] Superintendent, Filtration Division, Water Department, Sacramento, Calif.

SOCIETY AFFAIRS

THE FOUR STATES SECTION

On November 21, 1930 the Four States Section held a meeting at the DuPont, Biltmore Hotel, Wilmington, Del., Mr. Seth M. VanLoan, Deputy Chief Engineer of the Bureau of Water, Philadelphia, Pa. and Chairman of the Section, presiding.

One hundred and twenty-two members and guests attended.

Luncheon was served promptly at 12:30 P.M. in the DuBarry Room of the Hotel and the delegates were welcomed by the Hon. Geo. W. K. Forrest, Mayor of Wilmington.

C. P. Maroney, Jr., Chairman of the Board of Water Commissioners, Wilmington, Del., also gave a short interesting talk.

There was a short business session, at which a new set of By-Laws, drafted along the lines of the uniform By-Laws for all the Sections as suggested by the American Water Works Association, was adopted.

The principal speaker was Mr. W. C. Wills, Deputy Chief Engineer of the Wilmington Water Department. Mr. Wills very ably presented a paper briefly describing Wilmington's present water supply and its proposed future supply, which includes what is known as the "Old Mill Stream Project," which is now under construction.

Mr. Wills exhibited several reels of most interesting motion pictures showing the Old Mill Stream dam in various stages of construction.

After Mr. Wills' paper those delegates so desiring were furnished automobiles by the Wilmington Water Department and taken for an inspection trip over the project.

ABSTRACTS OF WATER WORKS LITERATURE[1]

Frank Hannan

Key: American Journal of Public Health, 12: 1, 16, January, 1922. The figure 12 refers to the volume, 1 to the number of the issue, and 16 to the page of the Journal.

Supreme Court Takes Stand on Depreciation Allowance. Eng. News-Rec., 104: 148, January 23, 1930. Allowance for depreciation in determining the rate base for a public utility cannot be limited by the original cost of the property owned by the utility, but should be determined on the basis of present value of the property, according to a decision rendered on January 6 by the U. S. Supreme Court in the case brought on appeal from a decree of the Court of Appeals of Maryland, which upheld an order of the State Public Service Commission limiting the rate to be charged by the United Railways and Electric Co., of Baltimore. The return, said the court, should be reasonably sufficient to assure confidence in the financial soundness of the utility, and should be adequate to maintain and support its credit and enable it to raise the money necessary for the proper discharge of its public duties. The court "is not certain that rates securing a return of 7½ or even 8 per cent on the value of the property would not be necessary to avoid confiscation." The depreciation allowance is defined as the amount necessary to be set aside periodically "to restore property worn out or impaired, so as to continuously maintain it as nearly as possible at the same level of efficiency for the public service." This calls for expenditures equal to the cost of the worn-out equipment at the time of its replacement and therefore should be based on present values. "It is the settled rule of this court that the rate base is present value and it would be wholly illogical to adopt a different rule for depreciation." Two dissenting opinions were written, contending that the annual depreciation charge should be based on original cost. The depreciation allowance had been set by the commission on the basis of the original cost of the plant.—*R. E. Thompson*.

Depreciation of Railroad Property. J. P. Snow. Eng. News-Rec., 104: 191–2, January 30, 1930. A discussion of the problem of computing, the depreciation of railroad property by the replacement and straight-line methods. —*R. E. Thompson*.

---

[1] Vacancies on the abstracting staff occur from time to time. Members desirous of coöperating in this work are earnestly requested to communicate with the chief abstractor, Frank Hannan, 285 Willow Avenue, Toronto 8, Ontario, Canada.

Revision Needed in Gunite Specifications. John V. Schaefer. Eng. News-Rec., 104: 108, 1930. The standard mix of 1:3 for gunite is the ideal one, but allowance should be made for sand bulking and the rebound, which amounts to not less than 25 per cent and consists almost wholly of sand. The practical limits of moisture in sand for cement gun work are 2 and 8 per cent: lower percentages cause dusting and higher percentages result in clogging of the gun.—*R. E. Thompson (Courtesy Chem. Abst.).*

Wood Lining Replaces Cast Iron in Shield-Driven Tunnel. Cont. Rec. and Eng. Rev., 43: 1422, December 4, 1929. The 2-mile shield-driven tunnel, 19 feet in diameter, being built at Detroit to supply the new Ford plant with water from the river Rouge, is being lined with 8- by 8-inch dense long-leaf yellow pine timbers, 4 feet long, beveled and fitted around periphery of the tunnel so as to be held in place by the pressure of the surrounding earth.—*R. E. Thompson.*

Value of Mechanical Ventilation in Tunnel Driving. Eng. News-Rec., 104: 74–5, January 9, 1930. Examples are given of ventilating practices in large and small tunnels of various lengths. In tunneling with pneumatic tools, ventilating equipment is not considered necessary when the distance from the heading face to portal or shaft does not exceed 100 feet.—*R. E. Thompson.*

Largest Underwater Tunnel Under Construction in England. Eng. News-Rec., 103: 1017–8, December 26, 1930. A brief description of a vehicular tunnel being constructed under Mersey River between Liverpool and Birkenhead which will be 2.16 miles long and 46 feet 3 inches in internal diameter in the under water section. The usual cast iron lining will be employed, sealed with cement grout and concreted inside and out. The estimated cost is approximately $25,000,000.—*R. E. Thompson.*

Driving the Shimizu Railway Tunnel in Japan. Eng. News-Rec., 104: 366, February 27, 1930. The headings of the Shimizu tunnel of the Japanese Government Railways were holed through in December last and at the end of the year the length completed was 31,213 feet out of a total length of 31,831 feet The work was commenced in 1922. In general the rock was hard and compact, but contained many seams or faults filled with soft material. A fissure discharging water at the rate of 12 second-feet was encountered in 1926, necessitating the driving of a drainage tunnel parallel with the main tunnel.—*R. E. Thompson.*

Driving the Tanna Railway Tunnel in Japan. Eng. News-Rec., 104: 67–72, February 27, 1930. A detailed description and discussion of the construction of the Tanna tunnel on the Japanese Government Railways, which is being driven through a volcanic formation of varying character broken by numerous faults. Owing to the many difficulties encountered, only about 75 per cent of the bore started in 1918 had been completed in June, 1929. The tunnel is 18 by 14 feet in section and 25,614 feet long. Because of the enormous

pressures encountered, a concrete lining 28 to 75 inches thick at the crown is required. Water at high pressures occurs in great volume in cavities along and above the line of the tunnel. At one time in 1925 the flow was as great as 123 second-feet. In 1926 a pressure of 275 pounds was encountered where impervious faults had obstructed the flow of the underground waters. In one case the drill and drill man were thrown 15 feet from the heading when the rod broke through into a water pocket. The methods employed and the difficulties met with are described at length.—*R. E. Thompson.*

Rapid Tunnel Work at Detroit. WILLIAM SMAILL. Eng. News-Rec., **104:** 376, February 27, 1930. Brief data are given on the rate of progress on the Detroit-Canada tunnel under the Detroit River. The shield is roughly 32 feet in diameter and 16 feet long, fitted with thirty 200-ton shoving jacks and twelve 25-ton platform jacks. On February 4th the shield was advanced 17½ feet in 24 hours. This means the manual handling of more than 570 cubic yards of stiff clay, loading it, getting it through the locks, hoisting it up the shaft, and loading it in trucks. An equivalent length of the steel segmented lining had also to be erected and bolted up.—*R. E. Thompson.*

Water Purification during the Past Year. N. J. HOWARD. Cont. Rec. and Eng. Rev., **43:** 1500–5, 1929. An extensive review of progress in water purification during 1929, which was featured by the extended use of Cl_2 in all stages of treatment. Chloro-recording scales and evaporators were installed at Toronto during the year to enable the use of one-ton containers of SO_2 for dechlorination, resulting in the cost of SO_2 being reduced from $148 to $127.50 per ton.—*R. E. Thompson* (*Courtesy Chem. Abst.*).

Responsibility for Ogden's Typhoid Outbreak Placed Upon Infected Milk. Eng. News-Rec., **104:** 95, January 16, 1930. A report presented to the Ogden Board of Commissioners by J. E. GREAVES and L. L. DAINES under date of August 12, 1929, holds that milk was the vehicle of infection in the typhoid fever outbreak in June last. The report urges that the limited number of cases (14 out of 30,000 to 40,000 using the water supply) is inconsistent with a water-borne epidemic. All those who contracted the disease, it is stated, had eaten at lunch stands which had a common milk supply, delivered in cans which were interchanged among them. The records show that a waiter at one of the counters was ill during the latter part of May and the first of June, and subsequently gave a positive blood Widal test. He had had typhoid fever some 45 years previously and his illness just prior to the epidemic, the authors say, may have been typhoid fever in mild form due to a certain degree of immunity carried over from his previous attack or due to his being a carrier.—*R. E. Thompson.*

Fifty-Year Rainfall Record at Seattle Shows Long Decline. Eng. News-Rec., **104:** 61, January 9, 1930. A graphical 50-year rainfall record for Seattle, Washington, supplied by W. C. MORSE, is given. Record shows that there is a downward trend which has continued many years. The water situation

(with particular reference to power) in the Northwest is more serious than is commonly recognized. Ground waters are much lower than at any previous time for which records are available, the glaciers have receded materially in the last few years, and the flow therefrom is gradually becoming less. The recession of a glacier is very slow and its growth is still slower.—*R. E. Thompson.*

Water Works and Sewerage Activities in Ontario. A. E. Berry. Cont. Rec. and Eng. Rev., **43**: 1510–3, 1929. A review of activities in Ontario in the field of water works and sewerage. Of a total of 328 urban municipalities only 16 of those with a population in excess of 1000 are without a public water supply. There are 308 systems supplying over 2,000,000 people, over 65 percent of the total population of the province. Sixty-eight per cent of these supplies are derived from surface sources, although the number of deep well supplies is increasing. There are now 86 municipalities served with filtered water from 60 filter plants, which supply 35 per cent of all the water consumed from public supplies. Chlorine is applied to 191 supplies, comprising 80 per cent of all water used for domestic purposes from public systems.—*R. E. Thompson* (*Courtesy Chem. Abst.*).

Board Picks Alternative Routes for Colorado Aqueduct. Eng. News-Rec., **104**: 59–60, January 9, 1930. The board of review which is to select the most feasible route for the proposed aqueduct to bring water from the Colorado River to southern California has recommended that preliminary location surveys and more detailed geological investigations be made along four tentatively selected routes to permit of more accurate comparative cost estimates. These lines would all require pumping lifts of various heights. There were 56 officially proposed routes, in addition to several suggested by private engineers. It was also recommended that the district engineers study the silt problem further and that the aqueduct location should provide for the possibility of future treatment works along the line. Apparent advantages of a dam across the river at either Bulls Head or Upper Parker are sufficient to justify additional surveys at these points to secure data for later accurate cost estimates. Provision of terminal storage at end of main aqueduct line was considered of great importance, and detailed study of various suggested sites was recommended. The possibility of intermediate storage along aqueduct line was considered of sufficient value to warrant study.—*R. E. Thompson.*

Durability of Portland Cement. Thaddeus Merriman. Eng. News-Rec., **104**: 62–4, 1930. A test is described for determining the durability of portland cement under conditions of outside exposure. Add 7.5 g. of the dry cement to 100 cc. of 15 per cent cane sugar solution which had been made N/10 with $Ca(OH)_2$ (phenolphthalein), shake for 2 hours, and filter. Titrate two 25-cc. aliquots of the filtrate with N/2 HCl, using phenolphthalein and methyl orange as indicators, respectively. The difference between the values so obtained (in cc.), the former being a measure of the total lime in solution and the latter, of the lime, iron, alumina, and silica, is termed the "index of disin-

tegration." Results obtained with 32 cements tested by Committee C-1 of the American Society for Testing Materials are given together with the results of 2- and 5-month exposures to 10 per cent Na_2SO_4 solutions. Only those cements having a low "index of distintegration" satisfactorily resisted the 2-month Na_2SO_4 test, the limiting value indicated in these experiments being 5.8. The Al_2O_3 content appears to have a bearing on the durability, the more resistant cements, in general, having the lower Al_2O_3 contents. The limiting Al_2O_3 content was approximately 5.7 per cent. It is noted that in making Na_2SO_4 exposure tests it is important to renew the solution when the caustic alkalinity is equivalent to N/10, otherwise the disintegrating action is inhibited.—*R. E. Thompson* (*Courtesy Chem. Abst.*).

Emergency Restoration of Manila Water Supply. A. GIDEON. Eng. News-Rec., **103**: 897, December 5, 1929. Record-breaking high water at the time of the typhoon that passed very close to Manila, Philippine Islands, September 3-4, 1929, washed out a river undercrossing in the conduit from the impounding reservoir at Montalban to the distribution reservoir near the city. A temporary connection from the new Novaliches impounding reservoir and aqueduct to the old conduit was made by means of ditches and wooden flumes to carry water over several ravines. The connection was completed in 36 hours by 600 men, working 24 hours per day in 2 shifts. Seven parallel lines of 12-inch cast iron pipe were then constructed, connecting the two systems.—*R. E. Thompson.*

Control of Boiler Water Treatment to Prevent Embrittlement. FREDERICK G. STRAUB. Mech. Eng., **51**: 366–7, 1929. From Chem. Abst., **23**: 4287, September 10, 1929. Boiler water should be analyzed to determine whether the sulfate-alkalinity ratio conforms to that recommended by the American Society of Mechanical Engineers' boiler construction code. If not, it should be treated to prevent embrittlement (cf. C. A., **23**: 2231). Either sodium sulfate in direct proportion to the alkalinity, or sodium phosphate at a definite set figure largely independent of the alkalinity, is usually employed as inhibiting agent. Rapid and simple determinations are required to check the treatment. Alkalinity is determined by titrating 100 cc. of the boiler water with 0.1 N sulfuric acid. Turbidimetric determination of sulfate is more suited to boiler rooms than the gravimetric determination; but, as the fineness of the precipitate depends on the manner of precipitation, it must be checked frequently against the gravimetric method. Phosphate is determined by measuring the volume of the precipitate of phosphomolybdate in a bulb having a graduated capillary tube, or, if convenient to heat the solutions, is determined by the following modified colorimetric method. Measure 50 cc. of sample into a 250-cc. volumetric flask with 10 cc. sulfuric acid (3 + 22). Add 5 cc. of molybdic acid solution (made by dissolving 125 grams of pure ammonium molybdate without heat in 2000 cc. water, adding slowly 75 cc. concentrated sulfuric acid, and making up to about 2500 cc. with water) followed by 5 cc. hydroquinone solution (made by dissolving 50 grams of pure hydroquinone in about 2500 cc. phosphate-free water to which 3 cc. of concentrated sulfuric acid is added). After 5 minutes, 15 cc. of carbonate-sulfite solution (made by

dissolving 1500 grams of commercial soda ash in 6000 cc. distilled water and adding 225 grams of sodium sulfite in 1500 cc. water) is added and the whole made up to volume with water. The blue color developed is compared with that formed in standard phosphate solutions treated in same manner. The stock phosphate solution is made by dissolving in water 0.1432 grams of secondary potassium phosphate dried at 105° for 3 hours, adding 5 cc. concentrated sulfuric acid and making up to 1000 cc. 1 cc. = 0.1 milligram phosphate. High iron content and certain highly colored organic substances interfere with this test. Comparisons must be made in 15 minutes after addition of the carbonate solution as the color faces. Method should be checked against the gravimetric determination.—*R. E. Thompson.*

Comparison of Methods of Determining Moisture in Sands. WM. R. JOHNSON. Proc. Am. Concrete Inst., 25: 261–79, 1929. From Chem. Abst., 23: 4318, September 10, 1929. The following methods were compared by testing in turn 3 samples of sand, each with 4 percentages of moisture: electrical resistance moisture meter, drying to constant weight in oven, drying to constant weight with denatured alcohol, displacement method using cylindrical container, displacement method using A. S. T. M. flask, specific gravity method using a salt solution hydrometer. The best results were obtained with the methods requiring the simplest manipulation, the drying methods ranking first in accuracy, the displacement methods next, and the hydrometer last.—*R. E. Thompson.*

Failures in Steam Boilers. ANTON POMP and PETER BARDENHEUER. Mitt. Kaiser-Wilhelm Inst. Eisenforsch. Düsseldorf, 11: 185–91, 1929. From Chem. Abst., 23: 4326, September 10, 1929. Three separate cases of failure were investigated. In one case the elastic limit of the rivet had been exceeded. This resulted in brittleness which had been promoted by high temperature and alkalinity of the priming water. In the second case the boiler was too shallow and the mechanical specifications for the material were deficient with respect to elastic limit and tenacity. In the third case a fissure had developed from corrosion initially started around the rivets which was promoted by the alkalinity of the priming water.—*R. E. Thompson.*

Testing Concrete for Absorption. FRED WEIGEL. Proc. Am. Concrete Inst., 25: 514–21, 1929. From Chem. Abst., 23: 4319, September 10, 1929. Permeability is the controlling factor with respect to the resistance of concrete to the effects of fire, freezing, and long periods of exposure to water and general weathering conditions. The samples, procedure, equipment, and results are discussed.—*R. E. Thompson.*

Fifteen Mile Falls Development. Eng. News-Rec., 104: 255, February 6, 1930. The first two hydro-electric projects to be developed by the Connecticut River Development Co. on the Connecticut River at Fifteen Mile Falls, near St. Johnsbury, Vt., were started in August, 1928, and are scheduled for completion in October, 1930. Both projects involve combination earthfill and gravity concrete dams about 175 feet high, with total development of 300,000

hp. On the lower project, now under construction, the 800-foot concrete overflow section has been completed. The non-overflow concrete section, the retaining wall 165 feet high between concrete and earth-fill sections, and the 275,000-cubic yard earthfill are still under construction. Over 250,000 cubic yards of concrete will be used in building the dam.—*R. E. Thompson.*

Saluda Dam. Eng. News-Rec., 104: 255, February 6, 1930. Approximately 9,500,000 of a total of 11,000,000 cubic yards has been placed in the Saluda hydraulic-fill dam under construction by the Lexington Water Power Co., near Columbia, S. C. Fill is now being made from trestle El. 353. The crest will be at El. 372. Impounding of water was commenced last September, and the lake is now at El. 304.22.—*R. E. Thompson.*

Furman Shoals Dam. Eng. News-Rec., 104: 255, February 6, 1930. Preliminary construction was begun late last fall on the Georgia Power Co.'s 60,000-hp. hydro-electric development at Furman Shoals, on the Oconee River, 5 miles north of Milledgeville, Ga. The dam will be 2,960 feet long with a concrete gravity section in the center and earth-fills on the ends. The maximum height will be 93 feet. Over 425,000 cubic yards of earth and 186,500 cubic yards of concrete will be required for the project. Completion is scheduled for the summer of 1931.—*R. E. Thompson.*

Iodine in North Carolina Public Water Supplies. J. W. PERRY. J. Elisha Mitchell Sci. Soc., 44: 87–9, 1928. From Chem. Abst., 23: 4757, October 10, 1929. The average iodine content of the public water supplies of 10 cities was 1.73 p.p.b.—*R. E. Thompson.*

Diablo Dam, Seattle Power Project. Eng. News-Rec., 104: 256, February 6, 1930. The Diablo dam is a constant angle arch nearly 400 feet high being built in the Skagit River gorge, 100 miles northeast of Seattle, as part of that city's hydro-electric development. Contract was awarded in September, 1927, completion of the work being scheduled for September, 1929. Although structure has been brought to full height for part of crest length, some months will be required for completion.—*R. E. Thompson.*

British Columbia Hydro-Electric Projects. Eng. News-Record, 104: 256, February 6, 1930. Construction work is under way on two projects in British Columbia that will ultimately make an additional 782,000 hp. available to the system of the British Columbia Electric Railway Co. The Ruskin project on Stave River will consist of a concrete gravity dam 184 feet high. Diversion works at the damsite have been finished and concrete is being poured, completion being scheduled for late in 1930. On the Bridge River project, construction to date has been confined to work on a 13,200-foot tunnel of 14 feet 3 inches diameter to have a capacity of 2,100 second-feet.—*R. E. Thompson.*

San Gabriel Dam. Eng. News-Rec., 104: 257, February, 6, 1930. The construction contract for the dam has been cancelled by the Los Angeles County Flood Control District as a result of the refusal of the State to grant

permission to build the proposed 500-foot concrete structure owing to the discovery of faulted and shattered foundation rock at the site. Exploration work by means of shafts and tunnels is being continued to determine the possibility of a different type of structure, with a view to securing some storage at the location where $3,000,000 has already been spent. It is thought that a rock-fill or earth dam supplemented by smaller dams upstream might provide sufficient total storage. Future work on this part of the flood control program awaits decision of the county board as to making the bond money available for these other uses.—*R. E. Thompson.*

Carpenter Hydro-Electric Development. Eng. News-Rec., 104: 255. February 6, 1930. The Carpenter hydro-electric development, under construction for the Arkansas Power and Light Co., is located on the Ouachita River 4 miles south of Hot Springs, Arkansas, immediately upstream from the company's Remmell project. The dam will be of the concrete gravity type, with maximum height of 115 feet and an over-all length of 1,164 feet. The reservoir formed will have an area of about 8,000 acres and an effective storage capacity of 95,000 acre-feet within the limits of the draw down. Construction was started in 1929 and completion is scheduled for the fall of 1931.—*R. E. Thompson.*

Salt Springs Dam. Eng. News-Rec., 104: 255, February 6, 1930. Dumping 125,000 cubic yards of rock a month, the Pacific Gas and Electric Co. has completed 50 per cent of this structure, which will form part of a hydro-electric project on the Mokelumne River in California. The derrick-placed rock section on the upstream face is well above the outlet level and it is planned to pour enough of the reinforced-concrete facing slabs to permit some storage during the coming season. This record-breaking rock-fill dam will be 328 feet high with a crest length of 1300 feet. It will contain approximately 3,000,000 cubic yards of rock, including 220,000 cubic yards in the derrick-placed portion on the upstream face, and will require 30,000 cubic yards of concrete in the facing slab. Completion is called for in 1931.—*R. E. Thompson.*

Conklingville Dam. Eng. News-Rec., 104: 257, February 6, 1930. Hydraulic sluicing has been completed on the earth dam being built by the Board of Hudson River Regulating District on the Sacandaga River at Conklingville, N. Y., and the rolled-fill topping will be finished as soon as the weather permits. The dam will contain 670,000 cubic yards of earth-fill and 120, 000 cubic yards of rock-fill. The power house is under way. The reservoir formed will cover an area of 42.3 square miles and will have a capacity of approximately 30 billion cubic feet.—*R. E. Thompson.*

Owyhee Reclamation Dam. Eng. News-Rec., 104: 258, February 6, 1930. During the year work progressed satisfactorily on the 522-foot Owyhee dam, being built in eastern Oregon for the U. S. Bureau of Reclamation. The 22-foot diameter 1,005-foot diversion tunnel was lined with concrete, as was the spillway shaft which makes the tunnel a part of the finished project. By the end of the year excavation in the canyon bottom was nearly completed, the

foundation having been uncovered for most of the prescribed area. Work on the dam as a whole was reported 25 per cent complete early in December.—*R. E. Thompson.*

Dallas Flood Protection. Eng. News-Rec., 104: 258, February 6, 1930. To restrain the Trinity River within a leveed channel for about 7 miles and thus permit the reclamation of a large portion of its valley for industrial development at Dallas, the city, county, and an old levee district are coöperating in a project now under construction. These levees will form a floodway 2,000 and 3,000 feet in width, with a dry-weather or low-water channel in the middle. Four pumping plants equipped with screw pumps will handle storm runoff in the reclaimed area at flood periods when the culverts through the levees are closed, the borrowpits in this area being utilized for water storage to reduce the pumpage requirement. Part of the old river channel through the city will be filled by pumping sand into it. The project will cost about $13,000,000.—*R. E. Thompson.*

Sanitary District of Chicago. Eng. News-Rec., 104: 258, February 6, 1930. Data are given in progress in sewage disposal works construction. Owing to the failure of a bond issue in December, 1928, the construction activities were practically suspended during the major portion of 1929. The Illinois Legislature, however, granted relief on July 1, 1929, by authorizing the issue of $27,000,000 of bonds for work on the government programs. Bonds amounting to $10,150,000 were sold in September and work was resumed in October.—*R. E. Thompson.*

New York City Water. Eng. News-Rec., 104: 256, February 6, 1930. Considerable progress was made in 1929 in the construction of the 20-mile water tunnel of the Board of Water Supply of the City of New York. This tunnel, to be concrete lined throughout, extends in rock about 500 feet below street level from Hill View reservoir at the city line in Yonkers into Brooklyn, passing under the East River at Rikers Island. Of the 19 shafts having an aggregate depth of 10,265 feet, there had been excavated at the end of the year 7,161 feet, and 6,331 feet had been lined with concrete. Nine of the shafts on the Long Island portion of the tunnel were sunk by compressed-air caissons through 100 feet of water-bearing sand and sealed into rock before progressing further with excavation of shafts without the use of air. Tunnel headings have been turned in 3 of the shafts and 4 others are nearly down to tunnel grade. The 4 contacts covering the construction of tunnel were awarded to one contractor on October 5, 1928, at a total estimated cost of $42,692,567. At the end of the year there had been estimated for payment on these contacts $5,291,846, or about 12.5 per cent of the total.—*R. E. Thompson.*

Hetch Hetchy Project. Eng. News-Record. 104: 256, February 6, 1930. San Francisco went through a prolonged drought last fall which focused public attention on the 29 miles of tunnel now being driven through the Coast Range mountains. In addition to the tunnels, 47.4 miles of steel pipe across the San Joaquin Valley will be needed to complete the aqueduct. The first

of the valley pipe lines, however, can be built in a relatively short time; hence the tunnels constitute the limiting factor on delivery of the mountain water supply. The main storage reservoir on the project, which has been completed for some years, was full even in the very dry year just past. The mountain water is now expected in San Francisco in the fall of 1932. Up to the end of the year the total advance in the several headings of the Coast Range tunnels had been 41,411 feet. During the fall the city was successful in selling the $41,000,000 in bonds voted a year ago for the purchase of the distribution system and other Spring Valley Water Co. properties. With ample funds now in hand for the completion of the Hetch Hetchy project and having settled the Spring Valley purchase problem, the city now for the first time in its history can look forward definitely to operating its own water supply system. Including the company purchase, the bond issues for the completed system total $120,000,000.—*R. E. Thompson.*

Wachusett-Coldbrook Tunnel, Boston. Eng. News-Rec., **104**: 257, February 6, 1930. Only 1½ miles of the 15-mile Wachusett-Coldbrook tunnel being driven for Boston's water supply remain to be holed through. Concrete lining of the bore will be commenced early this spring, and it is expected that most of it will be finished this year. Works for diverting Ware River Water into the tunnel are about half completed and probably will be finished this year. —*R. E. Thompson.*

Wanaque Aqueduct. Eng. News-Rec., **104**: 257, February 6, 1930. Completion in the very near future is expected of the Wanaque project of the North Jersey District Water Supply Commission. Construction has progressed to the point where it would be possible now to turn water into the entire 20.5-mile length of aqueduct. After the line has been formally tested and sterilized, it will be ready to deliver water, probably early in the spring. Contracts have been let for the construction and installation of the head-works and equipment at Wanaque, and it is expected that the contract for the construction of the balancing reservoir to be located near the lower portal of the Great Notch tunnel will be awarded in February.—*R. E. Thompson.*

Large Steel Conduit, Philadelphia. Eng. News-Rec., **104**: 257, February 6, 1930. Four out of seven miles of steel force main have been completed for the Philadelphia water works. The works finished to date includes 14,000 feet of 93-inch pipe , out of a total of 19,900, and 7,000 feet of 72-inch, out of 14,400 feet. The main runs from the Torresdale pumping station on the Delaware River to a distribution terminal.—*R. E. Thompson.*

Detroit Water Supply. Eng. News-Rec., **104**: 256, February 6,1930. Substantial progress has been made during the year on the construction of the additional water supply system which will augment the city's present facilities. The 10-mile concrete tunnel connecting the new Springwells station with the Detroit River is very nearly completed and the contact for the last 2,300 feet of 14-foot diameter tunnel will be let early in 1930. Work on the 150-foot rock tunnel, linking up this last section with the new intake under

construction in the Detroit River, has been under way for some time and tunnel excavation has proceeded some 1,000 feet. The shaft located at the junction of the tunnels has been completed to the ground surface. Work has been started on the construction of dikes to form a lagoon in which the intake structure will be located and on the substructure of the intake. At the Springwells station site, one 20,000,000-gallon unit of the filtered water reservoir is very nearly completed, and the concrete substructure for the filter plant is scheduled for completion early in the summer of 1930. The foundations for the pumping stations, power house, and generator plant are under construction. The expansion of the distribution system by 15 miles of steel water main from 48 to 72 inches in diameter is well under way. Completion of the entire project is expected about 1932.—*R. E. Thompson.*

Cobble Mountain Dam, Springfield, Mass. Eng. News-Rec., 104: 257, February 6, 1930. Sluicing has been commenced on the Cobble Mountain hydraulic-fill dam being built on Little River above Westfield, Mass., for Springfield's water supply. The fill will contain nearly 2,000,000 cubic yards of material and will rise 245 feet above the streambed, a record height for this type of dam. Excavation has been completed on the outlet tunnel, 7,100 feet long, which will also be a pressure tunnel for a power plant to be located at the headwaters of the present supply reservoir in Little River Gorge. Work is under way on the tunnel lining and power house construction.—*R. E. Thompson.*

Cleaning Brush in Vrynwy Aqueduct Lost and Found Again. J. R. DAVIDSON. Eng. News-Rec., 103: 1021, December 26, 1930. During the cleaning of the upper end of the Vrynwy aqueduct with the whalebone pipe brush, the rear or trailing element was missing when the machine was removed at the first hatchway chamber, 3½ miles from the starting point. After 3 months operation of the aqueduct with only a slight reduction in delivery it was decided to attempt recovery of the missing part. The remaining portion was again placed in the pipe at the same point as before and after traveling a distance of nearly 2 miles was heard to stop at a main stop valve, near a hatchway chamber. When the main was opened the missing element was found in front of the brush. The brush is moved by successive openings of sluice outlets in the main and it was found that the brush had come to rest with the rear element right over a sluice outlet, and while in this position water was being discharged through the sluice. Although the outlet is radial from the center of the pipe, it has a sharp bend, and the escaping water must have exerted a tangential force on the perimeter of the element, causing the whole element to revolve. Unfortunately this rotation took place in the opposite direction to the thread on the link connecting the back element, and it was evident that this had only 2 threads left in engagement when the brush moved forward, with the result that the back portion was left behind. The brush was not intended to revolve and no locking arrangement had been provided.—*R. E. Thompson.*

48-Inch Concrete Pipe Jacked Through Natural Ground Under Three Tracks. S. W. WORTHINGTON. Eng. News-Rec., 104: 294, February 13, 1930. In the

construction of a 20-inch water main crossing under a railroad line, a 48-inch reinforced concrete pipe was jacked through undisturbed, hard, blue glacial clay and the main laid inside. The pipe sections, 4 feet long, weighed 3500 pounds each. A total of 60 feet of pipe was placed, 12 feet in open cut and 48 feet by jacking. The labor cost was $668.42 (886½ hours).—*R. E. Thompson.*

Disease May Lurk in New Mains. L. D. St. John. American City, **43**: 2, 104, August, 1930. Short article advocating use of portable chlorinator for sterilizing new water mains, or water mains which have been repaired. It is pointed out that construction work may occur in ditches containing seepage from nearby sewers and hence it is imperative that pollution which enters the pipes be removed before mains are used. It is advocated that bacteriological samples be collected as check on chlorination procedure.—*C. R. Cox.*

Putting the Water Supply of Concord To Rights. P. P. Phillips. American City, **43**: 2, 123–26, August 1930. Originally water for Concord, N. C., was secured from wells; but in 1907 additional water was needed and Cold Water Creek was developed as source of supply. A one-million-gallon sedimentation basin and two tub type rapid sand filters were installed. This filter plant served the city until 1920, when filter capacity was increased to 1.5 m.g.d. A shortage in 1925 necessitated development of impounding reservoir on branch of Cold Water Creek, water from which was discharged into the creek in times of drought. A conventional earth dam was built to impound 343 million gallons. Precautions were taken to stock the reservoir with top feeding minnows to prevent prolific mosquito breeding. The old settling basin was converted to filtered water reservoir and new mixing chamber, coagulation basin, and gravity rapid sand filters were constructed and pumping facilities were renovated. The dam cost $46,000 and reconstructed filter plant cost $58,000.—*C. R. Cox.*

Twenty-one Years of Progress in Water Supply and Purification Practice. Nicholas S. Hill, Jr. American City, **43**: 3, September 1930. Marked advancement in steam-electric power generation has occurred in the last twenty-one years, resulting in 50 per cent reduction in fuel consumption per kilowatt-hour. Corresponding progress has been made in pump design from slow speed reciprocating pumping engines using saturated, or low-temperature superheated steam at low pressure, to modern turbine-driven centrifugal pumps utilizing high pressure steam. Synchronous motors of high efficiency and controlled power factor have proved decidedly economical. Appreciable savings may usually be effected in any pumping station over ten years old after careful study. Isolated wells of larger diameter, equipped with motor-driven deep-well centrifugal pumps, have largely replaced older installations of smaller wells pumped by air, as result of recent developments. Physical, chemical, and sanitary standards of water are much higher than formerly. Great improvements have been made in art of water treatment. The proportion of unfiltered surface supplies has decreased and more attention is given to sanitary control and to protection of watersheds. Mechanical filter plants have largely superseded slow sand filters, because of their lower first cost and their flexibility. Sterilization of water supplies with chlorine is a noteworthy

modern development. More attention is being given to removal of tastes and odors from water through use of aëration, superchlorination, ammonia-chlorine treatment, potassium permanganate, or activated carbon; or combinations of these. Water softening has been greatly improved through development of the excess lime treatment followed by recarbonation and also of the zeolite process. Mechanical filter plant design has been standardized and operation greatly improved and simplified. Mechanical clarifiers and other mechanical devices are being used to greater extent. Accurate dry feed machines have been developed. Mixing tanks are now considered necessary. Rates of filter washing have been increased somewhat.—*C. R. Cox.*

The Determination of Sulphate in Natural Waters and in Soil Extracts. SAPROMETOW, B. Bull. Univ. Asie Centrale, Taschkent, Russia; Chem. Zbl., 1928, **99**: 4, 385; Wass. u. Abwass., 1928, **25**: 2, 40. Comparative experiments proved that, of the usual methods for the determination of sulphuric acid, gravimetric as barium sulphate, iodometric by KOMAROWSKI's method, and MÜLLER's and RASCHIG's benzidine methods, RASCHIG's method, with simplifications suggested by the author, gives sufficient accuracy and is most suitable for routine analyses.—*M. H. Coblentz (Courtesy of the Department of Scientific and Industrial Research, Water Pollution research Board).*

Permanganate Method for the Determination of the Oxidisability of Organic Matter in Water and in Aqueous Soil Extracts containing Chlorides. J. N. ANTIPOV-KARATAËV. State Inst. Exp. Agric., Leningrad, Bull. Bur. Soils No. **3**: 1928; Proc. Inter. Soc. Soil Sci. 1929, **4**: 40; J. Soc. Chem. Indust., 1929, **48**: Brit. Chem. Abst. B. 571. To a 50 cc. sample are added 3 cc. 1:3 sulphuric acid and an excess of silver sulphate to precipitate the chlorides. The liquid is stirred occasionally and after at least 1 hour 10 cc. of 0.01 N potassium permanganate are added and the liquid heated gently for 10 minutes. If more permanganate is required, further heating is necessary. 10 cc. of 0.01 N oxalic acid are added and when the liquid has cleared the excess is titrated back with permanganate.—*M. H. Coblentz (Courtesy of the Department of Scientific and Industrial Research, Water Pollution Research Board).*

Apparatus for Taking Water Samples from Considerable Depths. B. L. ISSATSCHENKO. Inter. Rev. ges. Hydrobiol. u. Hydrog., 1929, **22**: 1/2, 95. The author found that the SCLAWO-CZAPLEWSKI apparatus could be made suitable if reconstructed for taking samples from considerable depths. As a results of alterations an apparatus was evolved which was considerably different from the original. A sketch and section drawings of the apparatus are given. The collecting tube is encased in a metal cyclinder with a screw at the foot to adjust different sized tubes to the right height. The cylinder has a firmly fixed lid and the drawn-out tip of the tube passes through a hole at the top of the cylinder. The cylinder is attached to a metal frame which is also fixed to the wire rope on the end of which is the sinking weight. The tip of the collecting tube lies on the top of this frame in such a position that a weight dropping down the wire rope crushes it and opens the tube. This apparatus can be used either alone or fixed to the draw rope of a water dipper.—*M. H.*

Coblentz (*Courtesy of the Department of Scientific and Industrial Research, Water Pollution Research Board*).

Improvement of the Smell and Taste of Drinking Water. F. Sierp. Tech. Gemeindebl., 1929, 32: 11, 153 and 12, 165. The article gives a summary of the literature on the cause and prevention of smell and taste in drinking water. *Smell and taste caused by algae and fungi.* Microscopical, in addition to physical and chemical examination, is necessary to determine the actual cause of such smell and taste. Experiments with copper sulphate and chlorine treatment have been carried out with differing results. Addition of chlorine often increases the evil. *Smell and taste caused by substances containing phenol.* Chlorination of drinking water, especially for the destruction of pathogenic germs in surface water, has become very widely used. If the least trace of phenol or its homologues is present, an unpleasant taste results. Phenol may be present in waste waters from coke, gas, brown coal, and tar works; in snow and rain in neighborhood of such works; or in water from tarred streets; or it may arise from sludge deposits in the river, or from protective paint or varnish coatings of pipes. In sludge deposits the destruction of organic matter gives rise to phenol, and certain bacteria belonging to *B. coli* group are phenol builders. At normal stages of the river which carries off the wastes and at normal temperatures phenol is rapidly decomposed; but severe frost or flood prevents the self-purifying action. Solutions of chlorine or of phenol alone give no taste in concentrations of 1:1,000,000; but a chlorophenol solution in concentration of 1:50,000,000 and even in some cases of 1:750,000,000 can be detected. The taste increases on heating the water. *Removing chlorophenol tastes.* By extraction methods, 90 per cent of phenol can be removed before trade effluents are discharged. Different processes have been tried to remove the taste. (*a*) Processes without excess chlorination. Replacing chlorine by ozone is successful but expensive. Krause's "oligodynamic" method does away with the need for chlorination. Methods by normal chlorination provide for the destruction of the chlorophenol by an oxidising substance, but the more widely used process is to add ammonia before chlorination, forming chloramine compounds which give no taste with phenol. (*b*) Processes with excess chlorination. A large excess of chlorine, given a long contact time and then removed, leaves no taste. Sodium thiosulphate, sulphurous acid, or its salts will remove the chlorine. Variations of the Adler method of filtration through active carbon for this purpose are described. If water has already been purified by rapid or slow filtration, an active carbon filter is sufficient without excess chlorination. Methods of employing and cleaning such a filter are described and detailed account of an experimental filter on a large scale installed by the Ruhr Federation is given. This has been found to remove not only chlorophenol tastes, but also other tastes arising from algae or mineral matter. Forty-six references to the literature of the subject are given. —*M. H. Coblentz* (*Courtesy of the Department of Scientific and Industrial Research, Water Pollution Research Board*).

Note on Dr. F. Sierp's Paper "Improvement of the Smell and Taste of Drinking Water." G. Nachtigall. Tech. Gemeindebl., 1929, 32: 13, 186. The

author calls attention to a remark in Sierp's paper which quotes him as recommending, for avoidance of chlorophenol tastes, a reduction of the chlorine dosage even at the cost of an unsatisfactory bacterial count. This is taken from a report of a paper, of which the full version appeared in Arch. f. Hygiene and is incorrect. The question dealt with is not that of chlorophenol tastes, which have not appeared in the Elbe water at Hamburg water works. Lowering of the chlorine dosage would not have the effect of removing the taste. The lowering of the chlorine dosage was recommended during a season of very low temperature because the chlorine absorbing power of the water had decreased with the temperature and the low content of bacteria rendered super-chlorination with subsequent dechlorination unnecessary.—*M. H. Coblentz* (*Courtesy of the Department of Scientific and Industrial Research, Water Pollution Research Board*).

The Depurit Process. "Dåbeg," pub. by Maschinen-fabrik A. G. Wien VI. 39 pp: Gesund. Ing., 1929, 52: 28, 521. The Depurit process is one by which a very highly activated carbon renders harmless the free chlorine which would otherwise give an unpleasant taste to drinking water. Excess chlorine for removing iron and manganese can thus be used. In Depurit filters there are formed free hydrochloric and carbonic acids which must be rendered harmless by alkalies in the water, or by passing the water over marble. The filter can be reactivated by treatment with soda solution. The chlorine addition is automatically regulated and the apparatus can be obtained in either fixed or portable form. The first plant on a large scale is to be erected at Aussig on the Elbe.—*M. H. Coblentz* (*Courtesy of the Department of Scientific and Industrial Research, Water Pollution Research Board*).

Chlorination of the Water Supply, especially for Tanneries. M. Auerbach. Collegium, 1929, 104; J. Soc. Chem. Indust., 1929, 48: Brit. Chem. Abst. B. 578. Chlorination may be effected by the direct method of passing gas into the water supply or by the indirect method of mixing water highly charged with chlorine with the supply. The usual amount for a drinking water is 0.1 -0.3 grams per cubic metre; but less suffices for a tannery water. Chlorinated water hinders putrefaction even when there is no free chlorine, and it does not injure the pelts. Chlorine is useful in deodorising and disinfecting tannery wastes. The amount required to destroy anthrax spores is large.—*M. H. Coblentz* (*Courtesy of the Department of Scientific and Industrial Research, Water Pollution Research Board.*)

Electrolysis. United Water Softeners Ltd. and E. B. Higgins, E. P. 311, 253. Ill. Off. J. Patents, 1929, No. 2111. A sterilizing agent consisting of monochloramine or dichloramine or both together and a relatively small proportion of free chlorine is obtained by electrolysis of a solution of an alkali metal chloride in the presence of ammonia or a soluble ammonium salt. The electrolysis can be carried out in a cell composed of an inner glass tube, enclosing two gauze electrodes, contained in an outer glass casing, into which the ammonium chloride crystals are introduced. The electrolyte fills the apparatus to the top of the inner tube. The chloramine liberated at the anode and the

hydrogen at the cathode are carried off together through an outlet, or the cathode is enclosed in a porous pot and the hydrogen withdrawn separately. Ammonium alum or di-ammonium hydrogen phosphate may be used as the ammonium salt. The electrodes may either be immersed in a solution of the ammonium salt with the alkali metal chloride between, or a solution of ammonia may be allowed to drip on the electrodes.—*M. H. Coblentz (Courtesy of the Department of Scientific and Industrial Research, Water Pollution Research Board).*

Small Filters for Household Use. STRUNK. Tech. Gemeindebl., 1929, 32: 10, 144. Small filters for household use where there is no regular controlled supply must fulfil two purposes, they must clear the water of suspended matter and they must remove bacteria. It is also necessary that purification, sterilization, and renewing of filter material shall be simple, convenient, and cheap. No filter in continuous use remains impervious to bacteria and therefore a filter material is necessary which can be easily sterilized by boiling. The earliest form of small filter used charcoal. Then with the use of clay and porcelain came true bacterial filters. China filters in candle shape were introduced by CHAMBERLAND and with a development of this, the Berkefield filter, with daily sterilizing a continuously germ-free filtrate can be counted on with a considerable degree of certainty. Other developments are the Doulton filter and one produced by the Seitz Works in Kreuznach, in which the filter material consists of specially prepared asbestos boards. The chief difficulty lies in the fact that, in spite of attention and purification, bacteria grow through the filter material and pollute the filtrate. This has been found to be preventable by the destruction of the bacteria in the filter by metals or metallic compounds, especially metallic silver. BECHHOLD has worked out an impregnating compound, the composition of which has not been divulged, and has tested its effect on filters of porcelain, kieselguhr, and charcoal. An impregnated kieselguhr candle-shaped filter worked five months giving an unexceptionably sterile filtrate. Experiments were made with a filter supplied by a Hamburg firm in which the filter material was made of kieselguhr, kaolin, and cement pressed into a metal case under heat while air was blown through under slight pressure. The filter core can be easily removed and renewed. The density of the filter was tested by blowing air through while the filter was immersed in water and the greatest pore width was calculated. The average rate of permeation per square centimeter of surface was determined by allowing tap water to run through under slight pressure. The removal of bacteria was found to be practically complete if the filter was sterilized before filtration; but frequent sterilization was necessary. The filter appeared good both for clarification and for removal of bacteria. It must, however, be made to fit the other requirements, ease and certainty of manipulation and cheapness. —*M. H. Coblentz (Courtesy of the Department of Scientific and Industrial Research, Water Pollution Research Board.*

Purification of Swimming Bath Water. Munic. Eng. San. Rec. and Munic. Motor. 1929, 84, 128. Illustration of Candy air-scour filter supplements previous description of Candy system of swimming pool water purification.

The sand filter is fitted with special drainage system, composed of earthenware pipes laid in rows in the floor, embedded in concrete, and fitted with brass plates into which nozzles are screwed. Recirculation through this filter effects great economies, both of water and also of coal for heating, as after the first heating only normal loss of heat requires to be made up.—*M. H. Coblentz (Courtesy of the Department of Scientific and Industrial Research, Water Pollution Research Board).*

The Thermal Waters of Vichy and their Important Physical and Chemical Properties. MANCEAU. Zbl. ges Hyg., 1928, 16: 690. Wass. u. Abwass., 1928, 25: 103. Fourteen springs of the Vichy basins, 5 natural and 9 bored, are used, giving a flow of about 700,000 litres per 24 hours. The water is sparkling and alkaline. The tertiary strata in which the collecting basins lie, and the principal physical and chemical properties of the water are described.—*M. H. Coblentz (Courtesy of the Department of Scientific and Industrial Research, Water Pollution Research Board).*

Water Supply in the Rhine-Westphalian Industrial District. FORDERREUTHER. Gesund. Ing., 1929, 52: 25, 441. Brief survey of industrial conditions of district, which contains iron, coal, and textile works. Density of population averages 600 per square kilometre while in one part, the Emscher district, it reaches 3,000 per square kilometre. Water requirements, domestic and industrial, are 2 million cubic metres daily. District is watered by rivers Wupper, Ruhr, Ems, Lippe, and Rhine and an account of condition of each is given.—*M. H. Coblentz (Courtesy of the Department of Scientific and Industrial Research, Water Pollution Research Board).*

Alkaline Sulphur Waters. A. ASTRUC. Bull. Soc. Sciences med. et biol. de Montpellier 1927, 8: 483; Zbl. ges. Hyg., 1928, 17: 3; Wass. u. Abwass, 1928, 25: 4, 102. The sulphur waters in France, which appear specially in the Pyrenees, contain unoxidized sulphur as hydrogen sulphide, hydrosulphides, acid and neutral sulphides and sulphur. There is frequently an appearance of silicic acid and sulphur algae with increase of temperature.—*M. H. Coblentz (Courtesy of the Department of Scientific and Industrial Research, Water Pollution Research Board).*

Purification and Preparation of Water. E. LINK. Z. Ver. Deutsch. Ing., 1929, 73: 553. Survey of the various processes used at present day for purifying water for drinking and industrial purposes.—*M. H. Coblentz (Courtesy of the Department of Scientific and Industrial Research, Water Pollution Research Board).*

Water Law and the Sugar Industry. GREVEMEYER. Deutsch. Zuckerindust., 1927, 52: 10, 265. Paper read at meeting of Technischer Verein für Zuckerfabrikanten in December 1926. Reich has no Water Law, but a Reich Waste Water Law is in preparation. Author dealt shortly with Water Laws of different states and more fully with Prussian Law of 1914 and its provision as to classification and registration of sources of water, ownership of water, and

rights and duties of owners and users of water courses. He discussed the establishment of a Reichsamt for testing effluents, treatment of the fluming waste waters from beet sugar factories, and removal of sludge.—*M. H. Coblentz (Courtesy of the Department of Scientific and Industrial Research, Water Pollution Research Board).*

The New Mecklenburg Water Law. A. Herzfeld Deutsch. Zuckerindust, 1928, **53**: 42, 1190. Summary of provisions of Water Law for Mecklenburg-Schwrin passed in 1928 (Regierungsblatt No. 48 for Mecklenburg-Schwerin, 9th July, 1928), with special reference to variations from Prussian Law of 1914, upon which it is based, and their bearing on beet sugar industry. The Prussian clause forbidding deposit of solid matter or sludge in a water course is strengthened to forbid introduction of water or other liquids which might cause harmful pollution, especially damage to fisheries, into any stream. This clause may be used by fishing interests to cause serious trouble to the beet sugar industry, as may also clause placing responsibility for upkeep and purification of streams on a specially formed Company, or on the owner, according to the class of stream. In Mecklenburg, though not in Prussia, a contractor can be charged for use of a stream and no limit is placed on the demands which the authorities hiring out the rights may make. This might lead to unbearable burdens on the industry. The authorities responsible under the new law are described and a short summary is given of the rights of action and appeal and of the legal fines and punishments.—*M. H. Coblentz (Courtesy of the Department of Scientific and Industrial Research, Water Pollution Research Board).*

Endless Sieve or Screen Band for the Removal of Solid Impurities from Water. A. Dittmeyer. D.R.P. 463,524. Deutsche Zuckerindust., 1928, **53**: 47, 1330. Such screens are generally inserted in clarification tanks and have a U-shaped iron piece for carrying their driving rollers. According to the patent, an L-shaped iron piece is added to this, in such a position that a channel is formed by the flanges of the pieces in which flat bars are so fixed as to prevent short-circuiting from clarification tank into pure water tank without flowing through the screen.—*M. H. Coblentz (Courtesy of the Department of Scientific and Industrial Research, Water Pollution Research Board).*

Coarse Screen with Mechanism for Cleaning for Polluted Water Channels. E. Geiger. D.R.P. 461,037. Deutsche Zuckerindust., 1928, **53**: 27, 798. Not only floating and suspended matter are held back, but also sand on the channel floor. Screen and scraping mechanism are supplied with an extension fixed above the channel floor and inclined over a depression therein. Extension is pierced with narrow slits through which the sand falls into the depression—*M. H. Coblentz (Courtesy of the Department of Scientific and Industrial Research, Water Pollution Research Board).*

Modern Methods of Chemical Purification of Drinking Water and the Application of Active Earth and Carbon. Koenig. Chem. Ztg., 1929, **53**: 51, 498. Magdeburg is forced to adopt bacteriological and chemical methods for purifying the Elbe water. Purification with chlorine was not sufficent. Ac-

tive carbon was better, but still insufficient and expensive. Iron content caused difficulties. New patented method using active earth (fullers' earth), which comes mainly from Bavaria, has had the desired effect on water purification. It can be used in established plant without serious alteration.—*M. H. Coblentz (Courtesy of the Department of Scientific and Industrial Research, Water Pollution Research Board).*

The Biological Self-Purification of Streams. R. Kolkwitz. Ber. d. deuts. Botanischen Gesells., 1928, **46**: 1, 35. It has been realized that variation in organisms in water is largely caused by chemical conditions. By the appearance of certain organisms one can now judge of saprobic conditions and often of salinity. There are many instances of sudden increase and decrease that seem more or less inexplicable. This is the case with *Sphaerotilans natans* and *Sph. fluitans* which appear in organically polluted waters and, given oxygen, increase and decrease with the food supply of organic matter especially of proteins, their decomposition products, and hydrocarbons. In purification by activated sludge, organic colloids absorb dissolved matter, and organisms, especially bacteria, regenerate the colloids to continue the process. *Sphaerotilus* is almost an indicator whether the counter-working of the two processes is satisfactory. If not, *Sphaerotilus* may increase and, by ramification, cause bulking of sludge. In nature, an activated or similar sludge can be found when the sludge lies loosely in places where it can be agitated by rain or by tides, as in the estuary of a river. Sludge therefore may exercise an added purifying effect and its removal may be harmful. *Sphaerotilus* has a tendency to collect detritus on the threads and clay between its flakes; colloidal sludge may, by absorbing nourishing matter, help in such cases to prevent fungus development. In difficult cases, where *Sphaerotilus* varies more or less mysteriously, the part played by colloids in the water, on the bed, or on the bank, should be investigated. They may cause not only the decrease of *Sphaerotilus*, but also the disturbance of other organisms and of their relations to one other.—*M. H. Coblentz (Courtesy of the Department of Scientific and Industrial Research, Water Pollution Research Board).*

New Methods for the Sterilization of Water. Katadyn. G. A. Krause, J. F. Bergmann, Münich, 1928, 20 pp. Authors describe the investigation of practical application of principle, discovered by Nägeli, that traces of certain metals so small as to be detectable only by the finest methods had a definite "oligodynamic" (as distinct from the "chemical-poisonous" action of metallic salts) action on bacteria in water. The quantities necessary are so small as to have no effect on human or animal life even with constant use. In working out a technical process for application of this metallic power, a special form of silver was prepared by inflation, or blasting, producing a non-colloidal silver of microcrystalline or submicroscopic structure with lamellar stratification, and therefore a very high ratio of volume to surface, increasing the oligodynamic effect to many times that of other forms. This special form of silver has been called "Katadyn." Investigations of the chemical aspects of its action are described. Comparative tests against others metals showing oligodynamic action proved that the effect with Katadyn was very much stronger

and quicker and the bactericidal power of the water after treatment, much greater. The effect can be still further increased in practice by passing water through a filter containing oligodynamic silver. Tests were made with a quartz sand filter permeable to bacteria and containing 10 per cent of silver. Forty litres a day of water containing 500,000 *B. coli* per cc. were passed through for three months. No loss of activity was found. Bacteria passing through the filter were killed inside one hour. Bacteria up to 2 million per cc. added to the filtered water were killed within from 3 to 4 hours. Berkefeld and asbestos filters treated with Katadyn showed the same power. Tests were made to determine if any substances normally present in water might protect bacteria from the action; but no such effect was found. No diminution of the effect followed upon continuous addition of very large quantities of bacteria. Loss of effect by solution of the silver in water was tested for by passing water over 1,500 grams of quartz sand containing 1.5 grams silver. After 58,000 litres of water had passed, it was found that 500,000 bacteria per cc. in 500 cc. of water were killed in 24 hours. After 98,000 litres of water had passed, the time for the same quantity was 48 hours. Process requires no attendance and is independent of temperature and therefore of climate. Once relation between amount of water and time is fixed, there is no possibility of over or under-dosing. The sterilized water does not deteriorate in freshness of taste or smell and receives no harmful additions. Previous filtration or settling is advisable with water containing much suspended matter. Methods are described for application of this principle to large and small quantities of water and for economy in use of silver. Two plates illustrating the formation of the Katadyn silver and tables of the results of analysis and experiment are given. *See also* **Oligodynamic Water Sterilisation by Katadyn Silver.** Gesund. Ing., 1929, **52**: 27. 500 Illustrations & bibliography.—*M. H. Coblentz* (*Courtesy of the Department of Scientific and Industrial Research Water Pollution Research Board*).

Need of Better Well and Spring Protection. CHARLES D. HOWARD. Health, New Hampshire State Board of Health, 14, August, 1929. Increasing use of wells for camps and suburban homes in the State has brought to light many sources of contamination due to faulty location and construction. The writer presents the essential features of a properly protected dug well, driven well, and spring, and notes on kinds of pipe to use, and methods of rendering a suspected water safe.—*A. W. Blohm* (*Courtesy U. S. P. H. Eng. Abst.*).

Purity of Drinking Waters from the Biological Aspect. W. RUSHTON. Surveyor, **76**: 1974, 513, November 22, 1929. This paper discusses the influence of geological formations upon the biological life of the waters with which they are in contact. Moorland waters, as is usual with peat waters, are slightly acid and almost free from algal growths and bacteria. The soft waters from the older rocks flowing in clear, stony stream beds are almost devoid of higher and lower plant life. Such waters, when impounded, give rise to sudden pulses of the small forms of life that are on the border line between plants and animals, such as peridinum, uroglena and daphnia. Disagreeable tastes and odors frequently result from such growths. In waters from the old red sand-

stone formation, filamentous algae such as ulothrix are fairly common as well as many of the unicellular types. Chalk waters are hard, colorless and have a higher CO_2 content. Consequently they are rich in plant life, and form the best fish-carrying streams. If taken from artesian wells, algae will develop rapidly in such waters unless protected from light. Water draining from cultivated land is generally high in organic content, thereby favoring plant and animal growths. The sequence of growth during the year follows that of the season. Diatoms appear in February, reach a maximum in April or May, then recede until August; green algae are highest in July and August and protozoa follow in September.—*A. W. Blohm (Courtesy U. S. P. H. Eng. Abst.).*

Disposal of Industrial Wastes. John D. Rue. Sewage Works Journal, 1: 3, 365, April, 1929. The article is confined principally to a statement of measures employed by the American Paper and Pulp Association in cooperating with various state authorities in finding practical means to keep paper mill wastes out of streams.—*A. W. Blohm (Courtesy U. S. P. H. Eng. Abst).*

Sources of Local Water Supply. A. Sonderlegger. Monthly Weather Review, 57: 9, 369, September, 1929. A discussion, illustrated with sketches and diagrams, of rainfall and its distribution in Southern California, rainfall cycles and their effect on surface and ground waters, rainfall as a source of water supply, the distribution of rainfall as surface run-off and ground water seepage and the effects of evaporation and transpiration on ground water. The formation of ground water basins in Southern California is discussed together with the effect of soil and topography on seepage and storage of ground water in these basins.—*A. W. Blohm (Courtesy U. S. P. H. Eng. Abst.).*

Safe Guarding Wisconsin Water Supplies. L. F. Warrick and O. J. Muegge. The Municipality, 24: 8, 265, October, 1929. (Published by League of Wisconsin Municipalities). Outlines work of Wisconsin State Board of Health and summarizes character of Wisconsin supplies. Underground possibilities of contamination and methods of protecting ground water supplies are discussed in detail. Reference is made to a typhoid outbreak caused by a cross connection.—*A. W. Blohm (Courtesy U. S. P. H. Eng. Abst.).*

Rule 72—A Regulation Requiring the Construction and Use of Public Water Supply Systems in Incorporated Cities and Towns When the Lack of Such Systems Results in Conditions Causative of Disease. Indiana State Board of Health, 32: 11, 170, November, 1929. Orders have been issued by the Indiana Board of Health that where investigations show that water supply systems are insanitary and causes of disease that the officers of the town after proper hearing before the Board shall construct or provide a satisfactory source of supply, distribution lines, and other appurtenances. *Rule 73*—Requiring the use of Proper and Adequate Treatment in Connection with Public Water Supplies Derived from Surface Sources: On account of the fact that all surface water supplies in Indiana are or may become contaminated it is ordered that wherever investigation shows such water does not meet the U. S. Public Health

Service standard the owner or operator of the supply shall proceed immediately to install treatment works that may be necessary to remedy conditions. —*A. W. Blohm* (*Courtesy U. S. P. H. Eng. Abst.*).

Ground Water in Yellowstone and Treasure Counties, Montana. G. M. Hall and C. S. Howard. (U. S. Geol. Survey, Water-Supply Paper 599 (1929).) Experiment Station Record, U. S. Dept. of Agriculture, **61**: 8, 773, December, 1929. "This report, prepared in cooperation with the Montana State College and State Board of Health and the Montana State engineer, deals with the physiography, geology, and underground water supplies of Yellowstone and Treasure Counties, constituting a combined area of 3,571 square miles in south-central Montana. Special attention is devoted to the development of the underground water supplies."—*A. W. Blohm* (*Courtesy U. S. P. H. Eng. Abstracts*).

Construction of Municipal Dam, Melfort. J. G. Schaeffer. Canadian Engineer, **57**: 21, 723, November 19, 1929. The inadequacy of the water supply of Melfort, Sask., derived from wells, became so acute during the summer of 1928 that immediate action to correct the situation became necessary. The town, which has a population of about 2,000, is a divisional point on the Canadian National Railway. It was desired to secure a supply which would not only meet the requirements of the town but also provide the railroad with an ample volume of water. The consulting engineers, Underwood and McLellan, recommended the damming of Melfort Creek to form a natural reservoir of 100,000,000 gals. capacity. Details of the work, which has now been completed, are given. The water will be treated with alum, passed through pressure filters and chlorinated. No information is given regarding the purification plant.—*A. W. Blohm* (*Courtesy U. S. P. H. Eng. Abst.*).

Experiences in Application of Alum in Coagulation. C. H. Burdick. Water Works Engineering, **82**: 23, 1629, November 6, 1929. Poor floc formations at certain times of the year regardless of the amount of alum added led to experiments of different types with the Baylis laboratory mixing machines. Results indicate time element between application of alum solution and the time the mixture of solution and raw water has reached a certain velocity is the important factor. The author refers to this time element as "The Stagnation Time." Conclusions are, one, alum solutions should not be allowed to lie stagnant in the water to be treated but should be stirred instantly; two, the effect of stagnation is lessened as the amount of required alum decreases; three, twenty to thirty seconds stagnation of alum solution is usually sufficient to produce poor coagulation.—*A. W. Blohm* (*Courtesy U. S. P. H. Eng. Abst.*).

The Present Typhoid Fever Problem. Anon. Illinois Health Quarterly, **1**: 3, 129, September, 1929. This article consists largely of a statistical analysis of the typhoid fever prevalence in Illinois during the last eight or ten years. It is clearly indicated that the present problem is largely confined to the smaller cities (population of 1,000 to 10,000) in the southern part of the State and in the ages from 5 to 25. It is suggested that efforts toward further reduction of

typhoid in Illinois be concentrated on the intermediate size towns in the southern end of the State, by the adoption of methods which have proved so successful in larger cities.—*A. W. Blohm (Courtesy U. S. P. H. Eng. Abst.).*

Wisconsin Waterworks, Sewerage and Refuse Disposal Code Second Revision. Revised 1929. Issued by Wisconsin State Board of Health, Bureau of Sanitary Engineering, Madison, Wisconsin. This is a 43 page leaflet issued in 1929. In it appears the general status of waterworks and sewerage in the State, the procedure of municipalities in the development and maintenance of waterworks and sewerage, including acts for financing. A complete outline of the rules and regulations of the State Board of Health is also given involving the general requirements for design and operation. Special emphasis is made as to new regulations regarding cross connections. The powers and duties of the State Board of Health, regarding waterworks, sewerage and refuse disposal are given in the appendix.—*A. W. Blohm (Courtesy U. S. P. H. Eng. Abst.).*

Public Health Organization and Administration in Hamburg, Germany. J. G. Townsend. Public Health Reports, 44: 47, 2487, November 22, 1929. *Water Supply.* Seventy-five per cent of water supply comes from 1000-foot wells and 25 per cent from Elbe River. Well water is treated by means of aeration and sand filtration for the removal of iron and manganese salts. Elbe water is treated by coagulation, sedimentation, slow sand filtration and chlorination.—*A. W. Blohm (Courtesy U. S. P. H. Eng. Abst).*

Public Health Activities in Ontario. Anon. Canadian Engineer, 57: 11, 389, September 10, 1929. A brief outline of the activities and powers of the Ontario Department of Health. There are 270 water systems in the province, over 75 per cent of the water used from these plants being chlorinated. All water treatment works are inspected on different occasions each year. The typhoid death rate is well below three per 100,000. This can, no doubt, be definitely attributed to the improvement in water supplies and the general advance in sanitation. In addition to the work in connection with water supplies, the Department's activities include approval and inspection of sewage plants, refuse disposal works, motor tourists camps, and all matters pertaining to sanitation.—*A. W. Blohm (Courtesy U. S. P. H. Eng. Abst.).*

Ring Worm of the Feet —A Disease of Swimming Pools. Anon. Health News. New York State Dept. of Health, 4: 48, 189, December 2, 1929. A foot infection known under various names is very common among users of swimming pools according to a report of the joint committee on bathing places presented to the Public Health Engineering Section of the American Public Health Association, on October 2. The following precautions are suggested: (1) Inspection of the feet and toes of all bathers and exclusion of those showing infection; (2) all equipment such as benches, stools, diving boards, steps, rubber mats and floors should be washed daily with a strong solution of chlorinated lime or soda. Canvas mats or pads should be abolished; (3) be certain that there is no exchange of unsterilized towels, suits, or bathing slippers.

Paper bathing slippers which may be discarded after use are now possible to obtain and can be recommended as an additional sanitary precaution.—*A. W. Blohm (Courtesy U. S. P. H. Eng. Abst.).*

Swimming Pool Disinfection. Chester G. Gillespie. Weekly Bulletin, California State Department of Public Health, **8**: 29, 1, August 24, 1929. An article discussing the various means of disinfecting swimming pools with particular emphasis on chlorine as the most important. Experience has shown that if the free chlorine is kept between 0.20 and 0.50 p.p.m. the best results are obtained. With over 0.20 p.p.m. of free chlorine the pool is in a disinfected state and less than 0.50 p.p.m. is not troublesome to the patron. The proper chlorine dosage depends on the patronage, temperature of the water, and the strength of the chlorine.—*A. W. Blohm (Courtesy U. S. P. H. Eng. Abst.).*

Plantar Warts and Ringworm of the Feet. Anon. City of Detroit Department of Health, Swimming Pool Review, **3**: 9, 1, September, 1929. The fungus producing ringworm is killed with difficulty on account of spores which resist long time boiling as well as usual germicides. No specific remedy is suggested except cleanliness about the pool and dressing rooms. The organism producing warts is easily killed by mild antiseptics and drying. That it is highly infectious is shown by the fact that warts out number ringworms infections five to one.—*A. W. Blohm (Courtesy U. S. P. H. Eng. Abst.).*

Iowa State Department of Health Swimming Pool Regulations. Anon. Journal American Association for Promoting Hygiene and Public Baths. **10**: 68, 1928. Plans for new pools and major changes are required to be approved by the Iowa State Department of Health in regulations adopted in 1927.—*A. W. Blohm (Courtesy U. S. P. H. Eng. Abst.).*

Detroit Adopts a New Standard for Swimming Pools. Anon. Weekly Health Review, Detroit Dept. of Health, **10**: 33, 1, August 17, 1929. The new standard is considered and reasons for its adoption presented. The standard is a bacteriological one—the average of the percentage of the samples showing total bacterial counts in excess of 200 per cc. and the percentage of the 10 cc. portions positive for B. coli shall not exceed 10 per cent.—*A. W. Blohm (Courtesy U. S. P. H. Eng. Abst.).*

The Helsingfors Swimming Pool. R. Kreuger. Tek. Foren. Finland Forh., **49**: 149–51 (1929). Chemical Abstracts, **23**: 21, 5258, November 10, 1929. "The purification system consists of an aerating tank, a filter for removing hair and a pressure filter. Cl gas (0.2 p.p.m.) is injected immediately after the filter so the water reaching the basin is free of bacteria. The daily heat losses are equiv. to a temperature drop of $\frac{1}{2}$–1°, which is made up by adding warm water."—*A. W. Blohm (Courtesy U. S. P. H. Eng. Abstracts).*

Court Decision Upholds Prohibition of Bathing in Wallingford Public Water Supply. Anon. Connecticut Health Bulletin, **43**: 8, 291, August, 1929. A

real estate development company is prohibited from utilizing a pond from which the public water supply of Wallingford, Connecticut, is taken as a bathing place according to a decision of the county superior court.—*A. W. Blohm* (*Courtesy U. S. P. H. Eng. Abst.*).

Bacterial Contamination of Baths. Anon. British Medical Journal, 3593, 915, November 16, 1929. Examinations of forty-two samples of the waters of five swimming pools which are not subjected to any process of filtration or chemical treatment and of 26 samples of the waters of two swimming pools treated by continuous filtration and chlorination have shown that B. coli multiply rapidly during the night in swimming baths, while streptococci do not. It is suggested, therefore, that an estimation of streptococci by glucose and lactose broth forms a better index of pollution than estimation of B. coli. It is concluded: (1) B. coli content is not a universally reliable index of intestinal pollution in swimming pools; (2) streptococci are constant indicators of intestinal pollution; (3) B. coli do not necessarily indicate pollution or danger, although their absence is an excellent index of safety.—*A. W. Blohm* (*Courtesy U. S. P. H. Eng. Abst.*).

Standards for Public Bathing Beaches and Wading Pools. Anon. American Journal of Public Health and the Nation's Health, 20: 1, 7, January, 1930. Report of the Joint Committee of the American Public Health Association and the Conference of State Sanitary Engineers presented at Minneapolis, Minn., October 1, 1929. Sanitary control of wading pools is discussed.—*A. W. Blohm* (*Courtesy U. S. P. H. Eng. Abst.*).

Keeping the Pool Clean and Sterile. C. A. Scott. Beach & Pool, 4: 1, 8, January, 1930. Any swimming pool is constantly collecting sediment, dirt, hair or other material from various sources. This may be either in suspension, floating or sediment at the bottom of the tank. Skimming will remove the floating material; filtration can be used for removing the suspended matter but neither of these operations will remove much of the sediment, hair and dirt which settles to the bottom of the pool. There has been developed a vacuum cleaning device which operates under water. For the larger pools a suction nozzle device now on the market will be found useful for this latter problem.—*A. W Blohm* (*Courtesy U. S. P. H. Eng. Abst.*).

Outdoor Swimming Pools. Stanley Pinel. Beach and Pool, 4: 1, 11, January, 1930. An illustrated article considering the various factors which govern the location, size, design and construction of outdoor swimming pools. A consideration of the restrictions governing impounding swimming pools such as the quality and volume of the water supply is followed by a discussion of three main types of artificial pools.—*A. W. Blohm* (*Courtesy U. S. P. H. Eng. Abst.*).

Stanford University Swimming Pools. Orvill H. Tucker. Western Construction News, 4: 20, 553, October 25, 1929. Swimming was recently placed among the important sports at Stanford University and three separate pools

were constructed adjacent to each other, the first designed to hold swimming races, the second for water polo, and the third for diving. The arrangement of the pools with a photograph is shown. The water circulation and purification is described briefly and a view is shown of some of the structural details of the tanks.—*A. W. Blohm (Courtesy U. S. P. H. Eng. Abst.)*.

Healthy Conditions Prevail in Toronto. A. B. Moffat. Canadian Engineer, 57: 8, 333, August 20, 1929. Comparing the years 1910 and 1928, the death rate in Toronto from typhoid has been reduced from 44.2 to 0.9 per 100,000. In addition to supervision of the water supply, the Department of Health has many activities. The milk supply is supervised for a radius of more than 100 miles outside the city, and inside the city rigid inspections are made of the distributing plants, samples being collected frequently. The milk and cream supply of the city is 99¾ per cent pasteurized under municipal inspection, and the remainder is certified.—*A. W. Blohm (Courtesy U. S. P. H. Eng. Abst.)*.

Annual Report, Ruhrverband, 1929. Karl Imhoff. 10. The annual report for the Ruhrverband for the year 1929 discusses the unusually difficult conditions which obtained during the year 1929, with reference to the amount of water available in the Ruhr. The report states that conditions became so serious at one time that for a period more water was actually being withdrawn from the Ruhr than it carried. Despite this condition, however, the filters are reported as not breaking down. The report further discusses the possibility, in times of stress, of pumping the water of the river Rhine, by stages, up the valley of the Ruhr.—*A. W. Blohm (Courtesy U. S. P. H. Eng. Abst.)*.

New Water Supply for Everett, Washington. J. W. Cunningham. Western Construction News, 4: 23, 649, December 10, 1929. In 1919, the water supply of Everett, Wash., was improved by constructing a 25-mile, 10 m.g.d. gravity pipe line from a mountain stream, the Sultan River, to the city. The line consisted mainly of 28-inch, untreated, continuous, wood-stave pipe, with steel pipe for the high heads near the river crossings. It has been found unsatisfactory on account of location and construction. With a present population of 38,000 and proposed new industries, a bond issue of $2,000,000 was voted for a new water supply which will be obtained from the same river, the intake to be located about ½ mile above the present one. The new development is to furnish 50 m.g.d. and includes the building of two tunnels, 7064 and 4414 feet long, the development of a storage lake and the construction of an entire new pipe line. The new line will be 3¼ miles shorter than the present line. Plans and profiles of the old and new lines are shown, with a description of the new water supply.—*A. W. Blohm (Courtesy U. S. P. H. Eng. Abst.)*.

Sanitary Aspects of Ground Water Supply and Distribution. J. L. Barron. Proceedings of Seventh Annual Water Works School, University of Kansas, 74: February, 1929. The numerous hazards to be guarded against in the development of ground water supplies is treated in this article by a discussion of shallow and deep wells and springs. Sanitary features of well location and construction are considered. The storage of initially safe water is said to be

of major importance from the standpoint of open tanks or reservoirs which may receive contamination by birds, animals, human negligence or of wind-borne origin. In discussing the distribution hazards the writer stresses the importance of new main sterilization as well as following repair work on broken pipes, valves and hydrants. Brief reference is made to the methods by which this disinfection may be accomplished and the advisability of checking results by orthotolidin test for residual chlorine. Instances are cited in which distribution systems have been dangerously polluted by defective sewer lines located nearby. The subject of cross connections, auxiliary intakes and by-passes is also included in this discussion by emphasizing the importance of such conditions in view of the frequent intestinal disease outbreaks caused thereby.—*A. W. Blohm (Courtesy U. S. P. H. Eng. Abst.).*

The Anticholera Campaign in Tonkin, 1926–1927. E. JOURDRAN. Far Eastern Assoc. Trop. Med. Trans. Seventh Congress, British India, 1927, **2**: 170. Tropical Diseases Bulletin, **27**: 1, 11, January, 1930. "The deltaic region of Tonkin, like that of Bengal, is a well known focus of cholera. Among the factors to which the epidemic of 1926–27 is ascribed, are the inundations of 1926 with subsequent famine. In the town of Haiphong the bursting of the drinking water channels and the mingling of that water with flood water was followed six days later by a marked rise in the mortality curve. A description is given of the efforts made to meet the epidemic conditions by means of general anticholera vaccine and general sanitary measures."—*A. W. Blohm (Courtesy U. S. P. H. Eng. Abst.).*

The Disinfectant Action of "Caporite." H. PIOTROWSKA. Gaz. i Woda, 1928, **8**: 228. Chim. et Indust., 1929, **22**: 270. Dept. of Scientific and Industrial Research, Water Pollution Research Summary of Current Literature, **3**: 2, 43, February, 1930. "'Caporite' is a chlorine compound containing, in addition to calcium hypochlorite, a certain quantity of free chlorine. The comparative disinfecting powers of phenol, 'caporite,' and bleaching powder are 100,120 and 35; 1.3 parts of 'caporite' are therefore sufficient to disinfect 1–2 million parts of water. Ten samples of water from different sources, with bacterial content varying between 199 and 12,500 per cc. were treated with 'caporite.' After one hour the number of bacteria was reduced, on an average, to 1 per cent."—*A. W. Blohm. (Courtesy U. S. P. H. Eng. Abst.).*

Iodine in Water, Food and Urine. H. W. CLARK and G. O. ADAMS. American Journal of Public Health, 1929. 10: 898–900. From Bull. Hyg., 5: 3, 240, March, 1930. Determinations of iodine content of drinking water and food in a given district indicated that water furnished but a very small part of iodine needed by the human body. Analyses of urine of different individuals in Massachusetts showed that it contains more than six times the amount of iodine found in the richest iodine-bearing water of the state. It is suggested, therefore, that food rather than water might be the more appropriate vehicle for iodine administration.—*Arthur P. Miller.*

Incidence of Goitre in School Children in the Hutt Valley. Shore. Rep. of the Director-General of Health, New Zealand, for Year ended 31st March, 1928, pp. 68–9. From Bull. Hyg. 5: 3, 240, March, 1930. In 1927, school children in the Hutt Valley near Wellington City, New Zealand, were examined for thyroid enlargements. A larger percentage of such enlargements occurred in schools located in districts supplied with drinking water from artesian wells than in those where supplies were drawn from surface water, or from shallow wells.—*Arthur P. Miller.*

A Goiter Survey of the High School Students of Contra Costa County, California. H. Lisser, H. Clare Shepardson and Rachel K. Miller. California & Western Med., 1929, 31: 33–8. From Bull. Hyg., 5: 3, 239, March, 1930. In examination of 3504 high school children in Contra Costa, California, in 1927, to determine goiter frequency, certain facts were noted which might indicate iodine deficiency as a factor in causing thyroid enlargement. Authors attempt to correlate variations in goiter incidence with variations in nature of water supplies.—*Arthur P. Miller.*

Endemic Goitre in Sweden. J. A. Hojer. Ztschr. f. Hyg. u. Infektionskr., 1929, 110: 239–55. From Bull. Hyg., 5: 3, 239, March, 1930. In investigation of possible causes of endemic goitre in strip of country 150 kilometers long and from 10 to 12 kilometers wide, across the south of Sweden, no relation was found between prevalence of goitre and either amount of iodine in drinking water, or likelihood of fecal contamination of water or food. There seemed to be some direct relation between amount of milk used and prevalence of goitre and an inverse relation between goitre frequency and amount of vegetables eaten.—*Arthur P Miller.*

The Iodine Content of Drinking Water in the Hamburg District. H. Schroder. Arch. f. Hyg., 1928, 100: 48–56. From Bull. Hyg., 4: 12, 1019, December, 1929. Four-fifths of drinking water supply of Hamburg comes from the Elbe and one-fifth from wells in outlying districts. Elbe water contains from 1.6 to 3.7 γ of iodine per litre, while well water contains up to 72 γ. There is a distinct correspondence between amount of iodine and that of chlorine in any sample of water.—*Arthur P. Miller.*

Investigations into Endemic Goitre and its Prevention. P. Mazzocco. Semana Med., 1930, 37: 356–73. From Bull. Hyg., 5: 8, 657–658, August, 1930. In 1924, National Health Department of Buenos Aires initiated work to determine iodine content of air, water, soil, dew, and articles of food in Salta, where goitre and cretinism are endemic, and in Buenos Aires, where they are not. Of twenty-eight water samples examined from Salta, maximum iodine content found was 2.5 γ per litre, while in province of Buenos Aires lowest, that of a well water, was 8.3 γ and highest, 32 γ per litre. Other results are given, but work may be summed up by stating that iodine content in areas where goitre was endemic was about half that in non-goitrous districts. —*Arthur P. Miller.*

The Amount of Iodine Consumed Daily by the Inhabitants of Salta. C. R. Soc. Biol., 1929, 102: 869; **The Iodine Content of the Air, Soil, Water and Food in a Goitrous Locality,** Ibid., 867–8; **Iodine Content of Sheep's Thyroids from the Province of Salta and from the Coastal Region.** Ibid., 870. P. MAZZOCCO. From Bull. of Hyg., 5: 8, 658, August, 1930. Data relative to iodine consumed in food by families in Salta are given. Air samples from Salta contained no detectable iodine, while similar samples from Buenos Aires contained 0.8 γ per 1000 litres. Soil from goitrous districts was found to contain from 140 to 400 γ per kilogram, while from Buenos Aires, a non-goitrous district, samples of soil showed as much as 1800 to 2800 γ. Water samples from Salta gave results of 0.35 to 0.6 γ per litre, whereas those from Buenos Aires showed 4.9 to 32 γ.—*Arthur P. Miller.*

Illinois River Studies. C. S. BORUFF. Ind. Eng. Chem., 22: 1252–5, 1930; cf. C. A., 24: 4105; 22: 2630; 19: 1745. Comparative sanitary survey of middle portion of river for summers of 1929–30 is given. Data indicate that biological O demand, dissolved O, and bacteriological load of a polluted stream are affected directly by volume of pollution, dilution, aëration from flow rate, and available O content. As would be expected, low water season of 1930 showed greater pollution than that of 1929, this based upon lower O content and higher bacteriological counts as criteria. Interesting curves are given.—*Edward S. Hopkins.* (*Courtesy Chem. Abst.*).

The Hampton, Kempton, and Walton Pumping Stations and Filtration Works of the Metropolitan, [London, Eng.] Water Board. H. F. CRONIN. Water and Water Engineering, 32: 378, 251–259; June 20, 1930. During year ending March 31, 1929, 58 per cent of London's water, about 159 million gallons per day, was taken from Thames through Hampton, Kempton Park, and Walton Water Works. Purification includes storage, usually; filtration, invariably; and chemical treatment, frequently; and in this order. Operation of slow sand filters at Hampton is described in detail. Difficulties experienced are due almost entirely to algae. With but short warning, large areas of filter beds may become blocked, necessitating overtime work and extra help to restore them to normal condition. No practical method of preventing algae growths in reservoirs has been discovered, but installation of primary rapid filters has eliminated the trouble from slow sand beds and increased their output per acre, thus reducing both capital and operating costs. Operating and other details of Walton primary filters are given in table. Average rate of filtration was 112 gallons per square foot per hour and maximum, 138; or 140 and 173, respectively, m.g.a.d. U. S. Filters run from a week to ten days and are then given about five minutes scouring with air under from 5 to 10 pounds pressure per square inch followed by upwash averaging 12,000 gallons water at velocity varying from 12 to 16 inches per minute. Experimentally, these filters were worked at 200-gallon (250-m.g.a.d. U. S.) rate for short period. It was found that at this higher rate, (1) percentage of wash water became 0.65 as against 0.36; (2) filter runs were 60 per cent shorter; and (3) loss of head immediately after washing was from 2 feet 9 inches to 3 feet, as against 1

foot 6 inches to 2 feet. Capital and operation costs of filtration are discussed. —*Arthur P. Miller.*

The South Teign Works of the Torquay Corporation. A. Gibson Low. Water and Water Engineering, **32**: 378, 260–265, June, 1930. These supplementary works are limited to maximum draft of 3,000,000, gallons from South Teign river in any one day. No water may be taken when river flow is less than 1,125,000 gallons per day; nor, except under special circumstances, during the annual salmon spawning season which lasts for five weeks. Design of measuring weir presented special difficulties and is described in detail. Interesting picture of fluctuations in flow of river during past twelve months due to various conditions is shown on recorder diagram. During minimum flow, fluctuation was most marked, amounting to as much as 4,000 gallons per hour, or 60 per cent, on average hourly flow of 62,000 gallons. Maximum daily run-off was found to occur between 10:30 a.m. and 12:00 noon and minimum, between 6:00 and 9:00 p.m. Tables showing rainfall and river discharge are given.—*Arthur P. Miller.*

Water Softening in South Africa. Chain of Installations on South African Railway's Karroo Section. Anon. Water and Water Engineering, **32**: 378 265, June 20, 1930. Plants to be erected must comply with following specifications: (1) Residual hardness of softened water shall not exceed 5 degrees (72 p.p.m.). (2) Plants shall be of vertical type, of not less than six hours sedimentation capacity, and so arranged that treated water will flow by gravity to locomotive feed tanks; (3) Reagent proportioning apparatus shall be automatic, of strong construction, and designed to deliver constant proportion of chemicals to raw water at all rates of flow from zero to maximum; and (4) Automatic cut-off arrangements shall be provided for interrupting raw water supply when soft water tank is full. Ten large plants are needed.—*Arthur P. Miller.*

The Selection and Operation of Pumping Machinery for Waterworks. F. E. F. Durham. Water and Water Engineering, **32**: 378, 266–272, June 20, 1930. Discussion is from economic standpoint. Selection must be governed by local conditions, major factors being (1) capital charges, depending on type of plant, including reserve units, and on computation of amortization; (2) fuel consumption per million gallons per foot head; and (3) wages. Each factor is discussed in considerable detail, and article is embellished with charts of engine efficiency, coal consumption, etc.—*Arthur P. Miller.*

NEW BOOKS

American Civil Engineers' Handbook. Editor in-chief, Thaddeus Merriman: Associate Editor-in-Chief, Thomas H. Wiggin. 5th. edition, thoroughly revised and enlarged. New York: John Wiley and Sons. London: Chapman and Hall, Ltd. Flexible; 4½ x 7 inches; pp. 2263. $8; or, in 2 volumes, $10. Reviewed in Eng. News-Rec., 104: 816, May 15, 1930.—*R. E. Thompson.*

Bacteriology. A Textbook of Fundamentals. STANLEY THOMAS. Cloth; 6 × 9 inches; pp. 301. $3. Reviewed in Eng. News-Rec., 105: 106, July 17, 1930, by HARRY E. JORDAN.—*R. E. Thompson.*

Methods of Chemical Analysis as Applied to Sewage and Sewage Effluents. Ministry of Health. 1929. London, H. M. S. O. From Bull. Hyg., 5: 1, 89, January 1930. In 1924 a conference was called by Ministry of Health (England) to consider unification of methods of sewage analysis. A committee of thirteen specialists under direction of one of Ministry's officers was appointed. It was decided to use as basis of the new work the methods of sewage analysis recommended by the Royal Commission on Sewage Disposal and as these were the result of work by Dr. MCGOWAN and his assistants, his inclusion on the new committee was very fortunate. He was asked to rewrite his previous work in light of new experience and results of research; present publication is the result. Report includes the committee's opinion as to manner in which results of analytical work should be expressed, and as to which tests should be included in laboratory work and which might be sufficient at small works.—*Arthur P. Miller.*

Water Softening. The Base-Exchange of Zeolite Process. Summary of Existing Knowledge. A. R. MARTIN. Dept. Scient. & Indust. Res., Water Pollution Res. Technical Paper No. 1. From Bull. Hyg. 5: 4, 293–294, April, 1930. Summary of present knowledge concerning merits and demerits of base exchange method of water softening as compared with lime-soda process, methods of preparing base exchange media, and work done on the theory of process.—*Arthur P. Miller.*

The Principles of Bacteriology and Immunity. W. W. C. TOPLEY and G. S. WILSON. 1929. London. From Bull. Hyg., 5: 2, 178–179, February, 1930. This book, which is in two volumes, devotes one entire volume to bacteria and the second to infection and resistance and to the application of bacteriology in medicine and hygiene.—*Arthur P. Miller.*

A System of Bacteriology in Relation to Medicine. Medical Research Council. 1929. London. From Bull. Hyg., 5: 2, 178, February, 1930. This publication is a comprehensive treatise on basteriology in the English language.—*Arthur P. Miller.*